1978

Information Systems for Natural Resources Managers: An Exercise in Interfacing

Connie L. Knapp
University of Rhode Island

INFORMATION SYSTEMS FOR NATURAL RESOURCES MANAGERS

AN EXERCISE IN INTERFACING

BY

CONNIE L. KNAPP

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

IN

GEOGRAPHY AND MARINE AFFAIRS

UNIVERSITY OF RHODE ISLAND

1978

MASTER OF ARTS THESIS

OF

CONNIE LYNN KNAPP

Approved:

Thesis Committee

Major Professor [illegible]

F X Cameron

Malcolm L. Spaulding

A. A. Nichol

Dean of the Graduate School

UNIVERSITY OF RHODE ISLAND

1978

ABSTRACT

An information system is an ordered combination of data bases, resources, and procedures to supply information about a particular set of problems or a field of interest. Most are developed by scientists and/or technicians who undertake to access these data and procedures to those with immediate or potential needs for such a tool. System users are often nontechnical by background. Hence, the most effective system designs must take into account the technical expertise of their users.

Information systems designed specifically to help natural resources managers carry out their decision-making responsibilities have been emerging at a fast rate. Relative to traditionally employed methodologies, however, few of these systems have made obvious improvements on the efficiency of the decision-making process. The reasons for this do not reflect environmental ignorance. Sophisticated models are constantly developed which further define ecological, sociological and econcmic relationships. But many of these have not been used outside the institutions which created them. One weakness lies in the inability of scientists to communicate, both facts and assumptions, in terms environmental managers can understand. Another reflects inadequate instruction on how to apply information and procedures to specific issues.

Information systems are, in themselves, an attempt by the scientific community to resolve the prcblems basic to

technology transfers. In fact, facilitating communication between technical and nontechnical sectors is emphasized by the majority of present-day systems concerned with the environment. Still, effective interfacing of the eventual user with the system developer has been demonstrated by relatively few of these efforts. Past experiences make it evident that the failure to incorporate specific user/developer interfacing mechanisms into the development process, can negate the ultimate utility of a system. Further, this can happen in spite of the technical capabilities of the system.

This thesis proposes guidelines for achieving the human interfaces which are requisite to the development and operation of natural resources information systems. Conclusions were drawn from an evaluation of past experiences in building and attempting to use these types of systems. Both successful and unsuccessful systems were considered, as well as the current effort in Rhode Island to develop a system for coastal resources managers. Examples are presented to support particular conclusions and recommendations. The perspective is nontechnical. Examples and recommendations, therefore, are conceptual rather than quantitative or technical.

While a variety of mechanisms can be used to achieve the required interfacing, the key to their selection is the end-user. User training programs and systematic consensus-reaching techniques are among the effective strategies. But these must be geared to the user and the user's organizational setting. The most successful systems have been dynamic, with the ability to respond to changing management needs.

ACKNOWLEDGEMENTS

This thesis was produced with the cooperation of many people. I particularly cite the generosity of Drs. Malcolm L. Spaulding and Peter C. Cornillon of the Department of Ocean Engineering. Without their guidance, ideas and procurement of funds, many aspects of this research would not have been possible.

The Center for Ocean Management Studies (COMS) and the Environmental Data and Information Service (EDIS) are particularly acknowledged for sponsoring a "Workshop on Information Systems for Coastal Zone Management". The views and experiences offered by participants in the workshop contributed greatly to the preparation of this thesis. A special thanks is also extended to the many contributers of facts and opinions on systems they have developed or used.

I am grateful to the members of my committee and especially to Dr. Niels West for his patience, timely advice and encouragement. Drs. Francis X. Cameron and Malcolm L. Spaulding also made useful suggestions for improving the manuscript.

Finally, I express tender thanks to my parents who provided constant moral support and an ideal place of seclusion for writing.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATICNS

INTRODUCTION

Man has long accepted that 'every action has its reaction'. But only in the last few decades of environmental consciousness has he been able to appreciate the complexity of this relationship.

Environmental managers are under great pressure to maintain a balance between resource exploitation and preservation. Similarily, scientists cf all disciplines are engulfed in the theoretical problem of representing the relationship between environmental uses and their natural and social settings. Unfortunately, traditional emphasis on the separation of disciplines, in order to better understand the world, is now manifest in our inability to reintegrate and apply these unique perspectives to broader issues of public policy and decision-making.

The needs of contemporary users of scientific and technical information in the area of natural resources management are not being adequately met. This discrepancy is recognized by many[1]. It is also evident in the lack of a standard approach to both environmental management and impact assessment. Strome and Lauer, among others, go further in suggesting that problems associated with transferring technology to environmental decision-makers are ultimately linked to weaknesses in motivation and communication.[2]

This widespread campaign to merge the technical and nontechnical aspects involved in environmental planning and management, has resulted in new and sophisticated methods of accessing information to the decision-making milieu. Although these new 'tools' fall under the general heading of 'information systems',[3] the diversity among individual systems is as great as among impact assessment techniques or resources management schemes, and their ultimate effects as difficult to measure.

Current interest in information systems reflects two primary concerns: 1) their potential boon to effective decision-making, and 2) their less than impressive "track record"[4] to date. It is apparent that many systems have failed to facilitate environmental decision-making to expected levels. Several systems receive little or no use at all.[5] Those that are used have generally survived with much difficulty and have yet to reach optimal utility levels.

This investigation delves into the matter of why information systems for environmental managers have not generally complemented management activities to the extent that their developers had intended. It would seem that recent efforts would exhibit greater success than is presently evident, due to the extensive groundwork already accomplished in the area of environmental information systems. But this is not the case. Information systems of all types and scopes continue to be developed and continue to encounter a common barrier: the lack of appropriate interfacing between the data suppliers, system developers, and information users (resources managers).[6]

It is clear that the key to a successful information system does not lie in its structural design, costs or even its data base, analytical capabilities or special user-to-system interface modes.[7] Existing systems (both operational and dormant) account for varied levels of attention to these factors and highly inconsistent use patterns. In the present study, this observation is examined more closely. The focus is on the crucial people-to-people interfaces, since these ultimately control not only what information enters the decision-making process, but how new informational procedures are incorporated into an existing organizational structure.

This report puts together lessons learned in interfacing as derived from the experiences of information systems of mixed scopes, designs and capabilties. These lessons reflect the nontechnical, management-oriented viewpoint often overlocked or given only minor consideration by system developers. That systems fcr the environmental decision-maker generally evolve through the coordinated efforts of technical personnel, is readily observed in the sophisticated technical designs of scme, and the lack cf management and planning interest in others.

Comparisons were made between 1) the various modes of interfacing used in operational and idle information systems, and 2) both the problems and positive aspects of particular systems. This exercise made it possible to then deduce conceptual guidelines that could benefit future efforts. The study particularly demonstrates the importance of conveying specific informational requirements to the developer and of instilling realistic expectations in the user.

II

METHODOLOGY

The research for this investigation consisted of two major efforts. These were:

1) to evaluate the general status of natural resource information systems, and establish a perspective that would enable more judicious analyses

2) to apply this perspective in drawing conclusions about how human interfaces can affect the development of a viable management tool

This thesis presents the findings of the latter effort. Although, the methodology section will cover each of the efforts in order to set the foundation for ensuing hypotheses and conclusions.

Part 1: Develop the Approach

Overall, the perspective adopted was nontechnical. The process of developing the approach was largely exploratory. It was defined by the collection and partitioning of facts and opinions about information systems.[8] Particular attention was directed to problem areas and probable causes. Aspects apparently requisite to high utility and/or continued operation of certain systems were also noted.[9] The question to which this part of the study adhered was: 'Why certain information systems are successful and others fail to meet the manager's informational needs or expectations."

The systems evaluated during the initial review accounted for a representative mix of the following major characteristics:

1. Stage of development - e.g; design, implementation, operational

2. Current (or final) status - e.g; never implemented, infrequently used, actively operational, total collapse

3. Scope - e.g; local, state, regional, national; coastal zone, land use

4. Users - e.g; citizens, institutions, government agencies, businesses

5. Developers - e.g; institutions, management agencies, private contractors

6. Sophistication, capabilities and structure - e.g; data processing techniques, output

7. Funding sources and terms - e.g; one-time allocations by planning/management agencies, research grants, on-going funding from user-agencies[10]

8. Objectives - [Other than to support natural resources decision-making.] - e.g; impact assessment, 'housekeeping,' graphic display of inventories, permit application review, etc.

Although the initial critique was broad in scope, it provided a cross-sectional view of problem areas for various types and classes of information systems. It also provided greater insight into the relationship between problems and possible preventative measures. The critique facilitated organizing, into more meaningful groups, the numerous concepts pertinent to the development of viable decision-making tools.

The chief motive for conducting the review was to assimilate sufficient background on past attempts to build information systems, to provide useful guidelines for a similar effort in Rhode Island. The development of Rhode Island's Coastal Information System, in turn, contributed first-hand experience. This experience was influential, both in directing the course of the research and in recognizing those factors which affect a system's end utility.

One main product evolved from this first review. This was a composite list of recommendations for avoiding problems often associated with the development or implementation of information systems. The list was subsequently expanded to include the relevant findings from other investigations of natural resources information systems. Four comparative studies contributed to the completion of the 'master criteria list'. This list is presented in Table 1.

TABLE 1

MASTER CRITERIA LIST FOR DEVELOPING VIABLE MANAGEMENT TOOLS

1. identify problems and informational needs
2. information should be problem-specific
3. objective should be to use information in making decisions
4. administrative basis for creating the system is crucial
5. organizational framework is crucial
6. information should be unbiased and value-neutral
7. assure accurate information
8. present information in small (human-size) chunks
9. establish priorities and proceed step-by-step
10. establish credibility by listing assumptions, as well as uses, of data and models
11. user-education is critical
12. user-oriented language is crucial
13. development site is critical
14. identify the user
15. early user-involvement is crucial; pre-proposal stage is best
16. assign "user-advocate"
17. information transfer from suppliers to users is critical
18. system should be simple to use and understand, and have useful products
19. computer models should parallel the thought process
20. consider legal ramifications of data and information

21. plan system implementation process early
22. reach consensus on all components, procedures, objectives, products, etc.
23. data collection is important
24. interdisciplinary view toward system and information is important
25. consider most specific user in determining data/information resolution
26. avoid excess information
27. incorporate better data analyses
28. user-oriented system is crucial; adapt the technique to the user
29. interfaces and networking of people are critical
30. maintain user-involvement
31. encourage user-feedback
32. make use of user-feedback
33. handle alternative solutions; play 'what if'
34. rapid access to information is crucial
35. plan for future expansion of system; build in 'flexibility'
36. consider system transferability (for use in other regions)
37. plan for system up-dating and editting
38. system should fit into existing decision-making framework
39. system must be cost effective
40. funding sources are critical
41. housing site is critical
42. match hardware and software to informational needs
43. quantify information when possible

44. systematic geographic referencing system is important

The criteria in Table 1 represent the conceptual elements that have been considered essential to 'model' information systems, by one or more authorities. This list, necessarily, consolidates a number of schools of thought. The ideas of system developers and users, plus other interested individuals, were incorporated. Hence, this list provided the basis for both the hypotheses and conclusions developed in this thesis.

The four comparative studies were instrumental in defining the perspective that would direct ensuing research activities. Effectively, this perspective is rooted in the master criteria list. The above studies are discussed, in relation to the approach taken in this thesis, in Appendix A. This appendix gives a detailed account of how each of the four studies contributed to the procedures described below. It also contrasts the various perspectives used by the respective investigators. A separate discussion was necessary in order to maintain the integrity of both the appended analysis, as well as this methodology section.

The approach taken in this thesis reflects the nontechnical perspective. Careful inspection of the 'master criteria list' led to the realization that major problems could almost always be traced to the lack of communication.

More specifically, the absence of adequate people-to-people interfacing mechanisms appeared to explain the majority of problems encountered while developing information systems. These mechanisms could also be linked to the difficulty in effecting the continued use of systems designed for resource managers.

While most problems stem from poor communication between the developer and user groups, some are not so easily explained. The failure of two systems, in particular, to maintain user support throughout the implementation and operation stages, suggests a more effective obstacle than user/developer reticence. The Intuitive Interactive Model (IIM) for New Jersey, and Rhode Island's Coastal Zone Information System, illustrate how unfavorable political environments can override concerted efforts to interface potential users with system developers. These examples also attest to the importance of introducing new procedures into a stable management setting. Both systems sustained management level interest throughout the development process. But internal, political problems seemed to build up to a point where the immediate need to deal with these problems became greater than the need to bring an information system into operation. While the IIM was eventually replaced with a more problem-specific system, the "Coastal Location Acceptibility Method" (CLAM), Rhode Island's system awaits a definite indication as to its implementation and use. Both systems are discussed further in the following sections.[11]

The above operations constitute the primary hypothesis addressed in this thesis. Subsequent tasks were readily defined. First, the relationship between human interfaces and the development of a viable management tool required substantiation. In addition, specific interfaces had to be identified. Finally, the analysis called for determining the mechanisms or procedures that would bring about the necessary interfaces.

The common approach to evaluating information systems consists of devising a list of 'model criteria' and applying it to individual systems. Relative to this list, judgements can then be made, either quantitatively or qualitatively, as to how well each criterion is satisfied in a given system. This type of approach characterizes each of the four comparative studies. It also defines the methodology used in the present investigation.

Some differences exist between the evaluation criteria defined both in previous studies and in this thesis. This can be attributed to the particular perspectives and approaches adopted by respective investigators. (See Appendix A.) Past studies have placed most weight on the technical elements that comprise information systems. In contrast, this thesis emphasized the nontechnical, or conceptual, components that were not completely addressed in the other approaches. Overall, the impetus behind each of the studies, including the present effort, was apparently linked to a common objective. This was to incorporate the lessons learned through past experiences, into the development strategies for anticipated systems.

One observation became increasingly clear in reviewing other comparative studies. This concerned the actual utility these efforts offered to the development of a general class of information systems. It was not evident how these studies could benefit other than the particular system which impelled the study, in spite of the technical specificity incorporated. This criticism is based on the length and dialect of the guidelines which are typically contained in studies of this nature. As Table 1 identifies, the present study is no exception. Many of the guidelines would not be directly applicable to more than a few information systems within any broad category. This makes their use cumbersome and undesirable, particularly for projects operating within tight time constraints.

In response to this observation, the present study attempted to simplify the 'master criteria list'. The purpose was twofold: 1) to derive a convenient framework from which to further evaluate interfacing mechanisms, and 2) to provide a practical set of rules which could be easily applied by prospective system developers. The scope of the investigation was modified accordingly, to focus on small-scale information systems (state coverage or less) for resource managers.

Trial and error partitioning of criteria resulted in the creation of a 'conceptual framework' of key criteria. This product indirectly accounts for the entire list of criteria presented in Table 1. The latter criteria were consolidated under five principles which appeared most crucial to the continuation of information systems. The criteria comprising the 'conceptual framework' also represent not only effective, but essential, interfacing mechanisms. Hence, this framework constitutes the remainder of the hypothesis to be tested in this thesis. It also solidifies the perspective employed in drawing conclusions.

Five criteria make up the conceptual framework as shown in Table 2.

TABLE 2

CONCEPTUAL FRAMEWORK

1. Involve the user from the beginning and maintain user involvement with the objective of reaching consensus on all aspects of the system

2. Design the system to fit directly into the user's legal/administrative framework

3. Establish system credibility

4. The system design should be flexible and future-oriented

5. The system must emphasize cost-effectiveness

Part 2: Implement the Approach

Phase two of the investigation concentrated on the application of the conceptual framework, plus its component criteria, to the specified group of information systems. More precisely, the range of people-to-people interfaces are examined in the context of the conceptual framework, in order: 1) to confirm the relationship between proper interfacing and the achievement of desired technical capabilities, as well as overall system utility; and 2) to indicate how the appropriate interfaces can best be achieved. As such, part two forms the substance of this thesis.

The significance of the conceptual framework to the evaluation of different information systems was in providing a standard reference. This allowed a systematic procedure to be instituted for: 1) tracing problem areas to specific interfacing deficiencies, and 2) tracing inadequate interfaces to actual or potential problems, including technical problems. For every system considered, an evaluation was made of how well each of the five conceptual criteria was satisfied. Where judgements showed inadequate attention to one of these concepts, further evaluations were based on the primary criteria (from Table 1) from which the concept was derived. Table 3 summarizes, in matrix form, the interdependencies between the primary, or component, criteria. It also shows the relationship of the master criteria list (Table 1) to its condensed form, the conceptual framework (Table 2).

TABLE 3

CRITERIA MATRIX SHOWING THE RELATIONSHIP

TO THE CONCEPTUAL FRAMEWORK

	1	2	3	4	5
1.	x	x			
2.	x	x			
3.	x	x			
4.	x	x			
5.		x			
6.			x		
7.			x		
8.			x		
9.	x		x		
10.	x		x		
11.	x		x		
12.	x		x		
13.	x		x		
14.	x	x	x		
15.	x	x	x		
16.	x	x	x		
17.	x	x	x		
18.	x	x	x		
19.	x	x	x		
20.	x	x	x		
21.	x	x	x		
22.	x	x	x		
23.	x		x	x	x
24.	x		x	x	x
25.	x		x	x	x
26.			x		x
27.			x		x
28.	x	x	x	x	x
29.	x	x	x	x	x
30.	x	x	x	x	x
31.	x	x	x	x	x
32.	x	x	x	x	x
33.		x	x	x	
34.		x	x		
35.				x	
36.				x	x
37.				x	x
38.		x	x		x
39.			x	x	x
40.	x				x
41.	x	x		x	
42.	x		x		x
43.		x		x	
44.			x	x	

Horizontal axis: 'conceptual framework' criteria (Table 2)

Vertical axis: component criteria (Table 1)

In refining the focus for part two of the study, the resources referral services and networks[12] and 'systems' which strictly manage data banks were recognized. However, these were not considered extensively. Generally, most systems which manage data banks also have data retrieval capabilities if not the total package of processing, analytical, and special output options.

Also deemphasized, particularly in tracing problem areas to interfaces and interfacing mechanisms, were the general purpose information systems. One example is the New England Energy Management Information System (NEEMIS), developed by the Massachusetts Institute of Technology. Another is the Environment-Dependent Management Process Automation and Simulation System (EDMPAS), plus its offshoot, Environmental Information Retrieval System (ENVIR),[13] developed by the Gulf Universities Research Consortium (GURC).

Although these commercial systems were initially considered, later discrimination was necessary in view of the scope required in part two of this thesis. These large-scale systems were more prone to technical problems than the small-scale, focused systems. This was also true of the regional and national efforts which attempted to incorporate data sets from geographically isolated areas.

Reference to regional, national and general purpose systems, then, was generally limited to demonstrating the importance of identifying the user, at the earliest possible stage in the design of the system, so that ensuing interfaces may be anticipated and properly met. High-level structuring is generally required to bring these types of systems into operation. This is particularly due to the complexities involved in integrating divergent user groups, organizational settings, data bases, and processing techniques. Clearly, the small-scale efforts (state coverage or less) have neither the need nor the resources to support such a comprehensive approach to accessing information to environmental decision-makers.[14]

A summary format is used in presenting the results of part two of this investigation. Findings which support the relationship between interfacing mechanisms and a system's usefulness to decision-makers, are expressed as guidelines or recommendations. In some instances, alternative courses of action are offered as well. Such advice is intended both for prospective system developers, and for potential system users. Hence, the organization of the material presented parallels the development of a decision-making tool for resource managers.

Due to the instructive nature of the text, most conclusions are substantiated in the notes. Some examples are incorporated into the text when the inclusion does not disrupt the logical progression of points. Finally, the sizable volume of results, relative to the purpose and perspective of this thesis, necessitated a selective documentation of examples. All recommendations and conclusions are supported either by representative examples derived from past experiences, or by other particularly illustrative evidence.

In summary, the following sections present empirical evidence of how certain interfacing methodologies have affected the utility or use of natural resources information systems -- either positively or adversely -- in the context of the conceptual framework. Procedures are recommended for establishing and maintaining the necessary interfaces to ensure the building of the most appropriate system. Examples are covered to demonstrate, or emphasize, the importance of these guidelines. The study is not only aimed at system developers, but at a specific class of users: the local and state level resource managers. However, the principles would be applicable to more extensive efforts as well. To facilitate easy reference, the material is arranged to follow the development process for the designated class of information systems.

III

ESTABLISHING THE INTERFACES DURING THE CONCEPTION OF AN INFORMATION SYSTEM

The decision to build an information system can be the most crucial step depending on the source and depth of the motive. As the examples will show, a continuing need for particular types of information or procedures must exist if a system is to achieve ongoing use.[15] Informational needs, to a great extent, dictate the specifications of a given system. The principle constraints appear to be time, money, and the presence or absence of particular human interfaces.

For natural resources managers, two types of informational needs are thus inferred. First, there is a need to collect information[16] on the resources themselves. Secondly, procedures may be necessary to generate or access timely information for decision-making purposes. Computers may be invoked to help interpret large amounts of diverse information to permit prompt decisions. Implicit also, in the recognition of informational needs, are the interfaces that must be established and maintained in order to properly meet those needs.

A. IDENTIFY INFORMATIONAL NEEDS

What determines the need for information? For environmental managers, information requirements often originate in the legislation which impels a particular management process and build through successive governmental actions.[17] State reactions to numerous federal programs[18] vary considerably depending upon the sentiments within the individual states.[19] These responses may account for the frequent confusion as to what the needs of decision-makers really are. Needs for information, or more timely access to information, generally accompany specific issues or problems that not only face resources managers, but also justify the existence of the management programs.[20]

The extent and nature of informational needs will vary with the management program. For a given management program, the informational needs will also change with successive stages in its development. Hence, the most appropriate information system design will depend on the timing of its introduction into the management process.[21] The resolution of information required during the policy planning stages, for example, is generally less than that needed to carry out the resulting management plan or to make decisions on a particular resource use.[22]

Thus, information systems that are to be implemented during the policy planning stages of a management program should be designed to also meet the specificity inherent in later management tasks. This precaution is necessary not only to maintain the system's utility,[23] but its source of funding as well. The potential merits to be derived by developing strictly a planning-oriented system, rather than one geared to daily management activities, warrants consideration at the time the decision to develop the information system is under discussion.

A question commonly omitted during the pre-proposal stage of an information system, is how the introduction of a new tool will enhance, rather than encumber, rational decision-making relative to currently employed methodologies. Participants in the Information Systems Workshop[24] reasoned that less successful systems were not sufficiently 'problem-oriented'. This implies that information systems should be founded on the need to resolve specific resource problems which cannot be adequately addressed through existing means. For a system to become 'problem-oriented' requires:

> 1) that specific problems be clearly defined prior to finalizing the design of the system, or
>
> 2) that the development of the system parallel the problem-identification process such that the design can be fined-tuned accordingly.

Hence, the failure to reach a consensus[25] on the issues, as furthered by poor user/developer communication, may preclude the ability to satisfy particular informational needs.

Developers of both the Minnesota Land Management Information System (MLMIS) and Louisiana's "Information

System" had difficulty determining informational needs.[26] However, these systems, by virtue of their internal development, did not suffer from a misconception of real issues as have some systems developed by outside contractors.[27] Internally developed information systems have an inherent advantage in growing out of the same philosophies which control the direction of the management program. While root problems may be difficult to pin, both the system and the management program will be similarly influenced by the impacts these problems create.

The Marine Information System (MIS)[28] depicts the opposite situation. This system evolved from a set of 'knowledge-requirements' that were determined by an outside contractor. Probably a direct result of disparate perspectives, the MIS succumbed to a simpler, internally developed system which answered the specific needs of the planning agency.[29]

Needs do not arise from the sudden availability of new procedures and/or stores of information. As the Coastal Plains Study pointed out,

> "Agency managers are constantly bombarded with new data handling approaches from private citizens, federal agencies, universities and their own staff. Each of these approaches demands an enormous commitment of financial and human resources for technology which may become rapidly outdated. Perhaps even more importantly, any new approach presents a new set of organizational obstacles with which to cope."[30]

One measure of the need to develop an information system is a financial commitment by the user-agency. Because management agencies are often criticized on how they spend their limited funds,[31] any direct investment can be considered an expression of a genuine need for new or more efficient methodologies.

This need, necessarily, will be rooted in legal and/or other administrative actions which define the responsibilities of the management agency. If the need is not linked to the organizational framework, there can be no guarantee of continued funding to keep the system operational within that framework.[32]

Although both the Intuitive Interactive Model (IIM) and the MIS received (outside) funding to support their development, and addressed -- what their contractors thought were -- priority needs, neither system was mandated, integrally tied to a management program, or requisite to the resolution of a given set of management problems. Consequently, neither were implemented and the available monies were funneled to other required or higher priority activities.[33] Both systems were, otherwise, considered technically sound.[34]

Three other systems -- the Washington Coastal Zone Atlas, Minnesota Land Management Information System (MLMIS), and Louisiana's "Information System" -- exemplify responses to either specific legislative actions or strong organizational encouragement.[35] In spite of high development costs and/or certain technical drawbacks,[36] these systems receive continued financial support from their respective user-agencies. In each case, the need for information to support decisions not cnly originated within the administrative framework, but was continually reinforced by the same structural environment.

The message conveyed in this section reflects a conceptual viewpoint. When the resource manager is not convinced that new tools are needed to help resolve specific problems, the decisicn to proceed with the development of an information system should be carefully reconsidered. The consequences cf acting when such a need does not exist may be more harmful than immediately apparent. Besides the expenditures cf manpower, time and money, there will most likely be an increased reluctance by decision-makers to back future efforts when a legitimate need for an information system arises.[37]

Clearly, it is during the pre-proposal stage that specific needs should be identified sc they can be made the foci of ensuing design activities. Alternatively, it would be feasible to justify developing an information system on general needs, as long as specific objectives were immediately established upon project approval.

The key to recognizing valid informational needs rests on the ability of scientists, resource users, and resource managers to communicate their respective concerns. While closer examination of this task is outside the intent of this thesis, the consensus-reaching methodologies discussed in Appendix B are particularly germane. Finally, with any particular information system, the expectations should only match the level of responsibility assigned to the user-agency, and the product should not become more than what is essential to meet these expectations.

B. IDENTIFY THE USER

Information systems that are not devised for particular users rarely achieve optimal use levels, if allowed to continue at all. This observation is widespread and is substantiated by the number of discontinued or infrequently used systems. Most national and commercially developed systems[39] show sporadic use patterns.[38] This is also true of the small-scale efforts which address a general class of users, such as planners, decision-makers, and/or citizens.[40] The majority of these 'generic' systems suffer largely because the final user must adapt to the demands of the system, rather than the reverse. This problem has yet to be recognized as a severe user-constraint by system developers, as well as prospective user-agencies.

Systems including, the Marine Environment and Resources Research and Management System (MERRMS), the Land Use and Natural Resources Inventory of New York State (LUNR), and the Oregon Map/Model System, provide excellent examples of the success that can result by identifying the end-user at the very beginning. These systems then followed through with a design that reflected the user's particular needs.

The task of conducting the LUNR inventory was first assigned to the Office of Planning Coordination (OPC) (now the Office of Planning Services (OPS)) in 1966, by Governor Rockefeller. The need for a consistent inventory originated in state government, e.g; within the administrative framework. But this inventory was not mandated to fulfill specific objectives. Cornell University's Center for Aerial Photographic Studies (CAPS) was contracted to develop the inventory "to be of prime use" to the CPC. Other planning agencies and individuals at the local level have since tied into the system. Though not all local efforts find it useful for their needs. LUNR's relevance to planning applications, its roots in the administrative structure, and its provision of low-cost, "accurate" information to users are most responsible for its continued use.[41]

It would seem that tagging potential users would be coincident with the determination that certain needs do, in fact, require an information system. However, user-identification has neither been a critical concern of, nor an easy task for, system developers in the past. Information needs that are conveyed solely through random interviews with different environmental authorities, and/or which must be sorted out by the develcper, are often misinterpreted. This results in a system which is of little use or utility to any specific management agency.[42]

Attempts like IIM, MIS, COVIRS and MLMIS[43] illustrate two major principles: 1) that 'real' needs for an information system are ultimately determined by the eventual user, and 2) that the user must be involved in the development process from the very beginning. Encouraging the user to help define his own informational needs, may effectively lead to his acceptance of a greater share of the burden to produce a useful tool. Commonly, it is the developer that incurs most, if not all, of the responsibility for the success of a system. This mutual goal-setting not only will facilitate continued user/developer interaction, but may motivate the user to take a more active role in the development process.

Tschanz and Kennedy advise that the "operational components of an information system and their linkages" be designed only after:

1. potential users have been defined
2. the level of service to the users is determined
3. system performance characteristics are specified
4. the form, structure, content, and availability of data are identified[44]

It has been further suggested that, "any system that is proposed must win support at a high level of decision-making..." and this "...requires an explicit, objective statement identifying the immediate users of the system."[45] A system which addresses questions that are defined by the eventual user is most likely to achieve this 'high-level' support.

Early and continuous user involvement becomes especially important when informational needs cannot be clearly defined at the time the project is authorized. Even though the need for an information system may be generally recognized, specific issues are requisite to producing a useful, problem-oriented system. Determining precise needs calls for considerable user input. This may occur during pre-proposal negotiations or as a first task in the development process.

The experiences of four systems, in particular, have demonstrated the importance of early user identification, including the formation of a working user/developer interface. In most cases, informational needs or objectives have been: 1) difficult to isolate and/or defined in broad terms, 2) misinterpreted, or 3) postponed for later determination, such as in the modular approach to development. Four examples are discussed below.

1. MLMIS. Upon starting the development of this system, a solid user interface was not established nor were clear-cut informational needs defined. The primary objective was to standardize, and to some extent centralize, the collection and storage of resource information used by different public agencies at the state level. This objective evolved from very general needs. One was to facilitate comparisons between data collected by various agencies. Another reflected the need to improve the communication and cooperation among related agencies. The resulting utility of the system fell below the expectations of both the developer and eventual user-agencies. Although, efforts have since been undertaken to salvage the direction

of the system by means of carefully selected tasks. A positive outlcok is attributable, in part, to the feedback provided through actual use experiences.

2. Louisiana's "Information System". This system, by virtue of its internal development, realized the advantages of the conventional user/developer interface without the corresponding expenditures of manpower. The identification of specific informational needs could be staggered to reflect the general progress of the developing management program.

3. Washington's Coastal Zone Atlas. An effective user/developer interface has served to offset the infraction of collecting overwhelming amounts of data without specific applications in mind.[46] The system is being developed according to a phased (or modular) plan, with methodologies installed as needed. Priority needs are established as an ongoing and cooperative effort between the user-agency and systems developers. Procedures have obviously been enacted which can handle the large stores of data within acceptable time frames.

4. Oregon's Map/Model System. The California Coastal Study noted that, "Map/Model started with a modest data base and data handling capabilities and added to these only when a system user specifically registered it."[47] This system has always been both problem and user-oriented, although there has been a regular turnover of users since its inception. Map/Model was initially designed and developed

in the specific context of a resource planning and management agency, the Columbia Region Association of Governments (CRAG). The system has since grown to serve a wide assortment of user-agencies. The Lane Council of Oregon Governments (LCOG) picked it up, shortly after CRAG shifted its planning efforts, and is essentially responsible for its current status. Needs have been clearly defined and effectively addressed on an incremental basis.[48]

In summary, the importance of identifying the end user, at the earliest possible stage, is rooted in the necessity to build the system which best answers particular informational needs. Such needs are predicated upon the responsibilities of the user-agency and are, thus, user-specific. User involvement throughout the development of an information system is vital in creating a tool that not only fits into the decision-making process, but that provides a service, without which the resources could not be properly managed. User invclvement -- which is, in itself, an interfacing mechanism -- must begin with the decision to build the information system.

Without this interface, there is a strong probability that the system will be discontinued -- or replaced, if the informational needs are genuine. The interface, once established, must then be maintained to ensure that the user's expectations for system performance dc not exceed the actual capabilities.[49] Finally, the importance of user involvement in overcoming attitudes of skepticism, toward highly technical or computerized methodologies, cannot be over emphasized.[50]

C. MATCH THE DEVELOPER AND SUPPORT REQUIREMENTS TO THE USER

When the developer and user are identical -- that is, belonging to the same organization -- the informational product is generally useful and nearly always sustained.[51] This success can be traced to several factors:

1. the system originates within the administrative framework
2. the user is involved from the beginning
3. attention to priority needs is implicit through direct user participation

Systems developed either entirely or in part by outside contractors, however, have exhibited a range of operational success -- from frequent use and continued support,[52] to complete dormancy.[53] While the blame for problematic or latent systems may be placed on any number of technical or procedural complications, the ultimate cause is almost always rooted in one of two related areas. Generally, the onus can be placed on the lack of communication between the potential user and system developer(s). Alternatively, untimely systems may yield to the inability of the developer to solidify communication channels, in spite of trying. This latter situation, however, is analogous to the most common violation of neglecting to establish the user/developer interface. The only difference is that the developer knowingly risks failure as a result of proceeding without securing the cooperation of a potential user.

Appropriate interfacing, therefore, must be established between the user and developer to ensure that information output and processing procedures can be tailored to specific management problems.[54] This means that the decision to build a system should be based on an evaluation of existing relationships between the proposed developer(s) and user-agency. Specifically, the capacity of these groups to work as 'co-developers' on the system should be determined.

It is important for the final contract to identify and procure the necessary expertise to fulfill the informational requirements at all levels.[55] With regard to the technical considerations, the developer has the responsibility to give the user the best choices available to meet his needs. The ability of a given developer to accurately convey the implications of alternative designs -- so that valid user-feedback may be obtained -- should weigh heavily in the decision to establish that interface over another.

An equally vital consideration, in resolving who should build the information system, is where the system will be built and eventually housed. The proximity of the user and developer can, in itself, determine the quality of the resulting interface. This is especially evidenced by the magnitude and similarity of the problems which surface during the implementation stage.[56] The 'distance factor' may take its toll in any number of ways. These will generally become evident under two broad headings:

1. the insufficient orientation of the developer to the total range of policy issues, in addition to the specific management needs[57]

2. the temporary avoidance of the staffing problem by the user-agency[58]

In settling on a developer and a building site, the question of how to take advantage of university skills and facilities warrants careful scrutiny. Most sources strongly discourage using university or applied research environments as development sites.[59] But some go further to suggest that outside organizations, such as consulting companies, should also be avoided.[60] Russell and Kneese take somewhat of an intermediate position:

> "Public management agencies at the state level especially will have needs which can probably best be met by developing internal capacity and through contracts with private research firms."[61]

They specifically maintain that universities cannot successfully carry out, "except under unusual circumstances," the multidisciplinary research and data collection necessary to provide useful information about natural systems. Thus, on top of being "too far removed from the manager's needs",[62] universities are not safe outside organizations to employ,

> "...because of the limitation imposed by departmental boundaries, the time constraints set by the needs of students, and a reward structure which puts a premium on small, short-term projects..."[63]

Hence, there appear to be no clearcut guidelines to apply in matching an appropriate develcper to a given set of management needs. When employing universities, it is advisable to exercise caution and to set, as a prime objective, the establishment of a mutually interactive user/developer interface.

The recent Rhode Island effort to provide the state Coastal Resources Management Council (CRMC) with an automized information management tool, exemplifies the risks involved in hiring universities as principle developers. In planning Rhode Island's "Information System", immediate informational needs were established, the feasibility of satisfying these needs were determined, and efforts were taken to involve the user-agency. However, progress came to a halt during the implementation of the first two components. This was largely the result of the Council's failure to participate more closely in designing the system, as well as in defining their real needs. It is possible that had a staff member (or "user-advocate") been assigned to the project from the start, interest in sustaining the system may have endured.[64] As mentioned earlier, however, user support of this project was suppressed as a result of the particularly unstable political situation in force.

Over the course of developing the two "highest priority" components, the CRMC did little to prepare for the eventual incorporation of new decision-making or management procedures. The Council apparently chose to maintain traditional practices rather than learn more efficient ways to perform their various duties.

Committing a user-advocate early in the project might have impelled the Council to take a more comprehensive approach to assessing their informational needs. In addition, the inexperience and part-time commitment of university personnel probably contributed to a general misinterpretation of needs.

The information and procedures made available through the system would have facilitated the resolution of certain management problems. But it became clear that the CRMC was able to satisfy basic responsibilities without them. This indicates that the perceived needs were either too superficial, or too transient, to justify investing in their long-term resolution. In general, this symptom should be heeded upon recognition, by either rectifying the interface or by abandoning the effort.

Overall, past experiences using universities for developing and/or housing sites have shown mixed results.[65] But the same is true for consulting firms. Generally, when explicit needs precipitate the development of an information system, the effort will be sustained -- with or without the original contractor. Establishing a healthy user/developer interface from the outset would increase the likelihood that the same contractor will be kept. Another advantage is that of producing a system that will be used.

Ongoing involvement may not be the objective of the contracting organization, particularly if the funding is in the form of a research grant or a one-time allocation. The common strategy is to implement various components, based on priority needs, and to contract out or renew exisiting arrangements accordingly, (as in the modular approach). Here is where it pays both the user and outside developer to establish a working interface from the beginning, and to follow through in maintaining it.

In contrast to the various arguments against external housing sites, it should be mentioned that agency-housed and managed systems bear as many criticisms -- generally over the quality of the information used.[66] Developers have found, however, that this distrust is reversible through proper data validation and methods documentation techniques, such as carried out by these systems:

> Land Use and Natural Resources Information System (LUNR)
>
> University of Virginia Information System (UVAIS)
>
> Washington Coastal Zone Atlas
>
> Environmental Management Decision Assistance System (EMDAS)

The consequences of inadequate quality assurance and/or documentation of models are evident in MLMIS and UPGRADE (a federal system).[67]

The greatest deterrent to authorizing any information system is cost. Although, nontechnical-oriented managers are often equally averse to backing highly computerized or structured systems, regardless of costs.[68] While the precise specifications of a system cannot always be known at the outset, anticipated high costs can negate the original 'perceived need' for new information or procedures. Achieving the tool that would best satisfy the user's needs at the lowest cost, therefore, means identifying and pricing other support requirements before the effort is confirmed.[69]

Similarly, the difficulty in acquiring the funds to maintain or improve existing information systems, demonstrates that system updates are too troublesome and/or expensive.

For over a decade, the LUNR system has been (and still is) providing low-cost information to mainly local New York managers. But it has not been updated since 1975. This was partially due to a recommendation, by an interagency Technical Subcommittee for the Land-Related Information Project in 1971, that a higher resolution system be developed to meet state informational needs. Although the committee has since broken up, plans to update LUNR have yet to be made.

Attention to cost-effectiveness was obvious throughout the development of LUNR. However, long-range planning proved cursory with respect to maintaining the system. According to the OPS, had the Federal Land Use Bill passed, LUNR would have long been updated.[70]

On the other hand, there is often insufficient information on the availability of, or the need for, certain design features. This prevents a realistic cost appraisal.

In such cases, the common practice is to agree to develop (or maintain) certain parts of a system only after special studies provide the justification to do so. This approach has been used by the Washington Coastal Zone Atlas System, Oregon's Map/Model, Rhode Island's Coastal Zone Information System, and EMDAS. It was proposed for the MIS and the Critical Resources Information Program (CRIP)[71] -- neither of which were developed. It was also followed in developing parts of the (now dormant) IIM.

While the nature of this investigation precludes a detailed discussion of system support requirements, it bears repeating that the user and developer must reach a consensus on all factors pertaining to the proposed effort. This must be done in order to sustain, not only a mutually interactive interface, but the utility of the informational product. Constant agreement on all aspects must start with the decison to build the system.[72]

A sound decision warrants a settlement on, at least, the following support requirements:[73]

DATA SETS	-	acquisition method, storage medium, resolution, coverage (spatial, temporal)
EQUIPMENT	-	based on: data handling methods, user access to system, informational products
MANPOWER	-	data suppliers/collectors, trained personnel, consultants
CONTEXTUAL	-	delivery schedule, secondary users or distribution, future directions, upkeep, transferability, training program

To summarize, the gravity of establishing an appropriate user/developer interface is manifest in the difficulty of transferring information between the interested disciplines and professions. The need to gear an information system to specific management problems, makes it essential tc identify the end-user, and to educate the developer as to the user's irformational needs.

Sometimes the optimal solution is for the management agency to develop the system internally, thus, avoiding the costs of an inefficient interface with an outside developer. Failure to devise the entire system -- including all capabilities, interfaces, and future directions -- around a principle user-agency, will almost certainly result in a problematic system. Further, such a system would be difficult to maintain on a continuous basis. Rowe et al. noted that the incorporation of an information processing technique into a user-environment "often requires more of an orientation of technique to user than user to technique."[74] This point has been developed by other authors as well.

In general, the ccmmitment of system support resources -- including staff, data suppliers and/or collectors, buildings, equipment, and data bases -- is seldom and directly addressed at the time it matters most: during pre-proposal deliberations. Even in the more successful systems, the appropriateness of the final arrangement seems to be more fortuitous than intentional. The ultimate utility of an information system is a function of its cost-effectiveness which, accordingly, must be understood from the very beginning.

IV. MEETING INTERFACE REQUIREMENTS DURING THE DESIGN AND DEVELOPMENT STAGES OF AN INFORMATION SYSTEM

As pointed out in one study of data processing systems,[75] the negative reactions and/or indifference of environmental authorities to the complexity and expense of information systems, often counteracts strong public encouragement to apply these tools.[76] What the authorities are conveying is that their needs do not provide them with the incentive it takes to learn a new approach or to take on a new set of organizational obstacles. Experience shows that problems of this nature have been characterisitic in taking on information systems.

The 'built-in' reluctance of managers is testimony to the repeated failure to orient the "technique to the user".[77] Clearly, both the attitude of decision-makers and the approach of developers need to be mutually adjusted. This will require not only time, but greater attention to the 'how' -- as opposed to the 'why' and 'what' -- of transferring information into a management setting.

Because a system itself is relative to the viewpoint of some observer,[78] how a particular representation is chosen must be explicitly stated. During the development of an information system, this theme is best carried out by involving the user. End-users who are not familiar with design and development operations cannot be expected to:

1. make valid judgements about the 'honesty' of the design -- for example, is the system honest in what it communicates or does?[79]

2. provide valid feedback to effect the development of a system that fits management needs in a decision-making context

3. make effective use of the system and its products[80]

The success of systems developed within the user-agencies, themselves, teaches the value of direct user-involvement. Proximity to the development site will influence the extent to which users take part in development activities.[81] Other factors, such as user skills and an eventual obligation to manage the system, will also regulate user-involvement. The most important element, however, is user-motivation. The user must be motivated to participate in the development process. This motivation does not come from outside the agency.[82]

Interfacing the user with the developer and system through all phases of development -- not just during implementation and operation, as is commonly done -- would enhance the utility of the system considerably. This may be accomplished by engaging "user-advocates"[83] and/or full-time middlemen (generally technicians).[84]

It has been noted that decision-makers rarely acquire the technical background on specific issues themselves.[85] The responsibility to operate (or make use of) an information system would probably also fall on staff or advisory members. Hence, it would be most efficient to assign these personnel to the project from the outset.[86] Such linkages are the key in helping user-agencies:

1. tailor the system to fit their needs and capabilties[87]

2. understand what the system can and cannot do to help them solve specific problems

3. accept the system within their decision-making framework

4. find the new techniques useful and apply them to management problems

Other mechanisms that have been employed (or proposed) for developing systems, smoothly and efficiently, are in the general category of 'consensus-reaching processes' or 'systematic decision-making techniques'. These are often initially geared toward data validation. But they also allow users and developers (and consultants) to reach a consensus and set priorities on other aspects of the system.

Although the implications of applying such techniques would seem beneficial,[88] their acceptance, as with any new approach, has been slow in taking hold.[89] Only four of the systems examined were based on a consensus-reaching process of some kind, and two of these never became operational. Appendix B gives an overview of decision-making techniques which apply to information system development.

Systems that were successfully structured through consensus-reaching methcdolcgies, include Louisiana's "Information System" and New Jersey's "CLAM", although the latter is a decision-making technique in itself. Experimentation with data validation techniques in developing the IIM, as directed by the AAA, proved futile except in pointing out that future attempts should focus more on the uses of the data, rather than the data itself, and perhaps save citizen invclvement for later in the development process.

The developers of MIS proposed a series of design methodologies -- as opposed to decision-making techniques. However, the comprehensiveness of their plan probably contributed to the final demise of the system.[90] The value of reaching a consensus and setting priorities on all aspects of information systems, was recognized by Tschanz and Kennedy, who cffered a general iterative design process and the explanation:

> "By iterating a decision-oriented set of tasks, the process leads to the specifications and implementation of the infcrmation system."[91]

While it is clear that the use rate of these techniques is slow, but nevertheless increasing, it is also clear that their effectiveness could be enhanced through "user-advocates". The agency must, however, commit staff members to this task on a permanent basis. This measure would ensure both the user-involvement, and the mutually interactive interfacing, which have been shown to be vital to the usefulness of systems. Again, time will be a main factor in effecting 'working interfaces' of this nature.[92]

The motivation to assign agency spokesmen, as evident in Louisiana's success with ISM (Interpretive Structural Modeling) and New Jersey's "CLAM", must originate within the administrative structure. In both of these systems, however, development was carried out 'in-house'. This means the user-advocate and the developer were synonomous, and no conscious effort to appoint the former was nesessary. The argument here is that "externally developed" systems may also realize similar benefits, if deliberate steps are taken to overcome interfacing problems. The user-advocate can play a crucial role in ameliorating difficulties in communication.

With or without a formal methodology, several principles of system design have proven critical to acquiring user acceptance of the final product. Knowledge as to precisely how and to what extent these criteria must be satisfied, can only come through adequate interfacing. The key design criteria listed below will be addressed:

1. simplicity

2. credibility

3. flexibility

Simplicity

A systems's simplicity is aimed at the user-to-system interface, since this is the mechanism which allows information to enter the decision-making environment. The importance of making an information system easy to use and intelligible to decision-makers[93] -- for example, communicating methodologies, assumptions, uses, output implications, and basic operating instructions, with "clarity and candor"[94] -- has been widely recognized among systems developers. But it has not been easily accomplished.

Most harmful to the utility of a system is the failure to structure models and procedures to transform information into a form compatible with the decision-maker's mental 'image' of specific problems. Models -- and systems -- which are too difficult to use, generally fall into this category. The need to design whole systems, as well as individual parts, to be understood in terms of the user's problems and mental model, is constantly affirmed.[95]

As would be expected, manually operated systems such as LUNR (aerial photographic overlays)[96] and MERRMS (four variable visual displays via slide projectors), have had greater success in acheiving 'simplicity' than computerized efforts. This is true in spite of attempts to link the user to computerized systems through various combinations of 'conversation', 'prompt' and 'query' modes.

Most large-scale (regional, federal, and commercial) systems have attempted to capitalize on the idea of sophisticated, interactive interfaces. This was mostly by necessity, for two reasons: 1) highly complex procedures are involved in handling (often incompatible) data bases, and 2) their main linkage to the outside user-community is on-line or time-sharing access by remote terminals. All of the large-scale systems examined in this study provide extensive user-prompting (e.g; for inexperienced users), and/or query modes (e.g; for knowledgeable users), in an english-language format.[97] For example:

> User-Prompted GRAPhic Data Evaluation (UPGRADE)
>
> Environmental Management Decision Assistance System (EMDAS)
>
> University of Virginia Information System (UVAIS)
>
> New England Energy Management Information System (NEEMIS)
>
> Socio-Economic Environmental Demographic Information System (SEEDIS)[98]

These modes are significant, however, in mimicking the very mechanisms which facilitate transfer of information and procedures between different people. Table 4 summarizes these mechanisms.

TABLE 4

INFORMATION TRANSFER MECHANISMS

1. use of a common language (English)
2. step-by-step instructions
3. opportunities for feedback
4. geared to the receiver's skills and prior knowledge of the topic[99]

State and local efforts have had better responses to these types of interfacing strategies. Though the mechanisms themselves have not been without problems. Interactive user/system interfaces are contained in the following small-scale systems:

Washington Coastal Zone Atlas

Louisiana's "Information System"

Minnesota Land Management Information System (MLMIS)

Rhode Island's Coastal Zone Information System

Oregon's Map/Model

Environmental Management Decision Assistance System (EMDAS)[100]

ORRMIS and the New Jersey Department of Environmental Protection's (DEP) "CLAM" have uniquely successful user/system interfaces as a result of their in-house development. Direct user familiarity with the procedures precludes their need for extensive prompting. It also allows these systems to be structured to the level of user competency -- a considerable saving of time and costs. In the case of ORRMIS, outsiders would be unable to directly interact with the system without grave misuses or inefficiencies.[101]

A secondary benefit of interactive interfaces (if properly done) is in giving automated systems a certain "didactic capability" -- allowing the users to educate themselves on the use and applications of the system.[102]

That a system may be simple to operate and the procedures readily understood, does not guarantee the data and/or output will be correctly interpreted or applied.[103] Not only does this call for clarity and simplicity of the information products,[104] but a common methodology for applying both the data and resulting information[105] to management problems must be provided.[106] These precautions are essential, particularly with respect to the legal and social ramifications of management decisions. Straus, among numerous others, recommends packaging information in small or "human-sized chunks". This will facilitate the consideration of several variables at at time, rather than presenting all-inclusive, incomprehensible products. This approach also permits answering "what if" questions in solving problems from system design to management issues.[107]

Credibility

Establishing system credibility is of paramount importance.[108] It is also most difficult to achieve without maintaining an adequate user/developer interface throughout development and implementation procedures. Computerized information systems and systems serving large user audiences can particularly attest to this dependency.[109] When measures are not taken to demonstrate the integrity of a system, user distrust in the output may overcome the cost-effectiveness of keeping the system operational.[110] User confidence in a system can be accomplished through data validation, software documentation, sensitivity analyses, and by clarifying assumptions, output, and operating procedures.

Due to a "great distrust of data out of context,"[111] and its progressive refinement from collector to end-user,[112] many developers spend considerable effort to assure that the data incorporated into their systems is accurate.[113] Even so, several large-scale projects, UPGRADE[114] and UVAIS, have had difficulty keeping up with data validation. This is due to the size of their data banks. UVAIS, in particular, has instituted a strict data selection and sorting process.[115] In general, developers' attention to documenting models and analytical procedures, also falls far short of what is required to instill sufficient trust in users. It is not surprising that nontechnical managers have difficulty accepting both the techniques and products of 'black-box' systems.[116] It should be noted that establishing credibility does not, in itself, determine the ultimate success of a system,[117] though it can seriously curb its usefulness.

It is apparent that establishing the credibility of a system is similar to effecting the transfer of information across an interface. The analogy is demonstrated by revising Table 4 as follows:

TABLE 5

MECHANISMS FOR ESTABLISHING CREDIBILITY

1. use of a common language (English)
2. step-by-step instructions
3. documentation of all steps
4. opportunities for feedback and consensus
5. geared to the user's skills and 'mental model'

Flexibility

Lillesand and Tyson made the comment, "Better maps don't necessarily result in better decisions; or even better assessments of environmental quality."[118] Such a conclusion may reflect the failure to clearly delineate assumptions and applications as mentioned above.[119] A more likely cause is the inability to develop a dynamic representation of spatially distributed variables which matches the resolution required by the user. Maps are outdated when completed, unless computer graphics capabilities are incorporated. The flexibility afforded by computers is especially critical when legislation or internal decisions redirect the focus of management functions and procedures.[120]

Despite their disadvantages -- inflexible nature, restrictive use, and costs of upkeep and preserving credibility[121] -- the development of increasing numbers of map-producing information systems, proves the value of these types of interfaces in transferring information into the decision-making environment.[122] Making maps the primary interface between information and information users, requires that there be a common agreement among the user, developer, and data suplier, on all aspects of the presentation. Failure to acquire this consensus may render the maps useless for decision-making purposes. [123]

What does the above discussion on maps offer to other areas of system design? In general, the lesson learned is to build a dynamic management tool. All parts and procedures[124] must be sufficiently flexible to accommodate changes in both user needs and scientific/technological methods. System flexibility should provide for the eventuality of additional data and capabilities, particularly in relation to modular development strategies.[125]

The benefits of involving end-users (including secondary and future users) in determining: 1) how much flexibility to incorporate, and 2) exactly how to incorporate it, cannot be over emphasized. For example, data compression for mapping or storage may be required by immediate users. However, this would reduce the flexibility of the system so it could not handle detailed mapping assignments in the future. On the other hand, the resolution that would be required by the most specific user, may not warrant the time and costs involved in encoding large amounts of primary data elements. Clearly, the accuracy and volume of data must be balanced at the outset, to meet both immediate objectives and long-range goals.[126]

The flexibility of systems developed in conjunction with developing resources management programs -- Louisiana's "Information System", MLMIS, Rhode Island's Coastal Zone Information System, and "CLAM", for example -- must be highly future-oriented, due to the likelihood of new legislation. This probability, plus an awareness that "the dynamic way to approach a problem is not through maps,"[127] has unfortunately, impelled few agencies (backing atlas production) to foster definite updating efforts. Two of the most successful systems, representing the extremes in cost-effectiveness -- the $2.5 million Washington Coastal Zone Atlas, and the relatively 'low-cost' store of LUNR aerial photographic overlays -- have no plans for routine update, although both systems are designed to allow this.[128] The problem is rooted in the inability to secure maintenance and operating support at the time the system receives development monies. Efforts which proceed without a continued source of income, risk dormancy as they become outdated. ENVIR and COVIRS are examples.

Flexibility also applies to the uses of a system. Most interactive systems give their users considerable freedom and control in all areas of data manipulation -- from input and storage to retrieval and output.[129] Ellis et al. observed that "Single purpose systems can be designed to operate with greater efficiency. But they cannot respond to needs beyond their narrowly intended purpose."[130]

Standardization of geographic references and variable catalogues is one means of providing flexibility. It allows systems to become multi-purpose when the need for greater capabilities arises. It also facilitates incorporating different data bases, expanding the area of coverage (from local to statewide, for example), or transferring procedures and/or data for use in other regions.[131] These needs (or objectives), however, due to their decisive effect on data compression methods, require joint assessments early in the project.[132] It is crucial that both immediate and long-range user needs be carefully matched to the technical and economic feasibilities of satisfying them. Failure to do this during design and development stages may seriously restrict the later utility of a system.

In review, the key message in this section is people-to-people interfacing. The goal should be to select and carry out an approach to system development that will instill confidence in the user. Ideally, the design and development process should evolve directly from the needs and interfaces defined during the conceptualization stage of the system. Through mutual feedback and systematic consensus-reaching methods, it is possible to coordinate the most useful and cost-effective information system. The parties required to accomplish this include the following: end-users (via special "user-advocates"), system developers, and any 'agreed upon' consultants, such as data suppliers/collectors, environmental authorities, lawyers, and/or citizens. Particular attention should be given to the 'how' of an information transfer as opposed to the 'what'. For example, the simplicity, credibility, and flexibility of a system constitute vital considerations. It is the 'how' that ultimately determines whether informational products will be 1) accepted into the decision-making framework, and 2) used to their intended potential.

V. MAINTAINING INTERFACES DURING THE IMPLEMENTATION STAGE OF AN INFORMATION SYSTEM

As shown in the previous discussions, the final utility and use of an information system may bear no relationship to the elegance or simplicity of its structural blueprint, nor to the size or quality of its data base. Other variables, such as political climate, attitudes and needs of resource managers, and financial resources, also affect the fate of the system and the quality of its development. The single-most important factor in the entire effort to incorporate the information system into the decision-making process, was found to be the end-user. That a user-oriented system is required to ensure its continued utility has been demonstrated.

In this final section, the focus is on user-oriented safeguards. 'Safeguards' refers to the criteria both making up and associated with the conceptual framework.[133] The term also includes the following interfacing mechanisms:

> 1. provisions built into the system itself, e.g; interactive conversational modes, English language, user's 'mental model'
>
> 2. the allottment of resources specific to the implementation process, e.g; technicians, user-advocates, instruction manuals and programs
>
> 3. provisions of a contractual nature, e.g; delivery schedule and conditions, ready access, formal consensus-reaching techniques, user-feedback mechanisms

When these safeguards are not considered during the design and development phases of an information system, implementation objectives can be counteracted.

The key message is stated in the heading: maintaining interfaces. While the end-user is invaluable in the implemention of an information system, the most effective user/developer interfaces for bringing a system into use, are those that have grown with the system. Postponing the formation of this interface until implementation could be harmful to the system in several ways. These are indicated in Table 6.

TABLE 6

CONSEQUENCES OF DELAYING THE USER/DEVELOPER INTERFACE UNTIL IMPLEMENTATION

1. actual use may be postponed while the user learns how to use and apply the system from scratch

2. user confidence in the system may be more difficult to establish[134]

3. it may be too late to modify end capabilities and products that are found to fall short of the user's expectations or needs

Clearly, most of these problems could be avoided through the user's committment to development activities. Even so, specific implementation procedures are necessary to ensure that the system fits into the decision-making framework, and that the user is satisfied with the outcome.

The user must be able to operate the system (through whatever means were provided). He must also know how to interpret the output, and apply it to management issues in a timely, effective manner.

The task is to form the user/system interface through a user training program. Maintaining control over the user's interface with the system, through the developer or other appointed technician, is vital during this stage -- regardless of the user's prior familiarity with operational blueprints. Tschanz and Kennedy point out that negative experiences incident to implementation have, historically, outnumbered positive ones, and that this was generally because user access and/or training were ignored during the design and development phases.[135]

An automated interface between the user-agency and a remote information system[136] provides a certain "didactic capability". However, this neither substitutes for the user/developer exchange during a system's development, nor later, during its implementation. These mechanized linkages will only be effective in teaching the user how to use the system, through prior user/developer interfacing of a suitable nature.[137]

LUNR's PLANMAP II and the MLMIS models referred to earlier, are illustrative of how difficulties in use or application can reduce both user confidence and interest, in certain components of a system.[138] New Jersey's Department of Environmental Protection (DEP) has, likewise, made little use of UPGRADE's remote facilities. This is in spite of UPGRADE's sophisticated user/system interface and the availability of computer-oriented personnel within the DEP.[139]

There is common knowledge of the relationship: "The sophistication and complexity of the user/developer interface increases with the sophistication and complexity of the information system itself.[140] But it has seldom provoked extensive user education as part of system development programs. Either time frames are not structured to allow the developer to follow through with implementation requirements,[141] or the user-agency prolongs the process by not being prepared for staff changes. Complications can be expected when user-agencies do not designate "user-advocates" to the project early in its development.[142] Systems developed on a modular, or incremental plan -- Oregon's Map/Model, Rhode Island's Coastal Zone Information System, and EMDAS, for example -- have had the best results. This has been accomplished by the presentation of discreet, 'easier-to-digest' parcels, as opposed to the delivery of whole, complex systems.[143]

Existing systems employ a range of interfacing mechanisms for implementing new components and/or taking on new users. Most are the result of an 'after-the-fact' recognition of the need for systematic methods of educating the user. Most also fall into the general category of the user-to-system 'interactive conversation modes', discussed earlier.[144] The best method for instilling enough confidence in users to ensure a system's utility, however, has proven to be the provision of experienced personnel and progressive training services of some kind.[145]

Implementation through a user training program has a threefold purpose. It is aimed at minimizing the consequences of breaking off (or ignoring) the user/developer interface during this critical transition period, (see Table 6). Table 7 lists the key objectives of this process.

TABLE 7

OBJECTIVES OF USER TRAINING PROGRAMS

1. teach the user how to operate the equipment and system access methods

2. teach the user to take a quantitative perspective in problem-solving, including how the new information and procedures can be applied toward that end[146]

3. provide the opportunity for user-feedback as a result of actual use experiences, and refine unsatisfactory aspects as required, to meet the user's skills, expectations, and decision-making framework

As Table 7 indicates, meaningful user-feedback should follow logically from the activities of user/developer interfacing and user training. The efficiency with which user-feedback could be obtained, however, would obviously be greatest when users are already acquainted with system mechanics and capabilities. The experience would be implicit through active user-participation in choosing and carrying out development strategies. Without early user-involvement, the need for a more structured introductory program is indicated.

Hence, constant user-involvement leads to greater system utility by directing development specifically to the user. This may be accomplished through consensus-reaching methods and mutual feedback between the user and developer(s). In addition, it lends to a smoother implementation than would occur, if user-oriented refinements were not carried out as part of the development program. Instilling confidence in the user, by minimizing interruptions during implementation, is a precautionary strategem worth the planning.[147] Tschanz and Kennedy associate the occurence of large numbers of problems in operational, agency-specific systems, with the disregard for factors basic to the long-term survival of these tools.[148] These factors are the conceptual criteria which have been emphasized throughout this thesis.[149]

In retrospect, there should be an overall plan for building an information system. This plan should integrate a user education program and interim delivery products within the continuing development of the system. It is also best to devise a plan that would not excessively delay the implementation of the system.[150] The precise approach is, necessarily, contingent upon the setting and nature of individual projects. But it should be predicated on people-to-people interfacing methodologies.

There are manifold problems that could be encountered while attempting to implement an information system or break in new users. A thorough appreciation would require recalling the realm of examples contained in the previous sections of this thesis. Suffice to mention that attention must be given to the conceptual framework (Table 1), plus its constituent criteria: the user-oriented safeguards.[151] Emphasis should be placed on user training programs. Activities concerned with satisfying these conceptual criteria define an ongoing process. The process must start with pre-proposal deliberations and be carried through the implementation and early operation stages of the system. Failure to do this adequately can lead to irreversible problems that may not show up until the system is implemented. The implementation itself, must be well thought out early in the development process. This will help to ensure that all activities which precede the implementation, are directed toward maximizing the efficiency with which this final process is executed. The latter being a requisite measure in procuring user-acceptance and continued use of a system.

VI. SUMMARY AND CONCLUSIONS

To accomplish the timely supply of intelligible, concise information, requires the careful matching of the information system and its interfaces, to the decision-making environment in which it serves. In general, each information system builds upon a unique set of objectives and resources. The structure necessary to establish and operate a resource management program, usually emerges from the administrative guidelines. It is within this structure that detailed informational requirements begin to take form. They are determined by the types of decisions that must be made during the program, who will be making those decisions, and which management techniques will be employed. Of course, they are ultimately determined by the nature and extent of the natural resource, itself.

Environmental information transfer is a serious matter at all jurisdictional levels. Research may produce an accurate model for a particular management problem. But, unless that model is structured in such a way as to speak to the concerns of the legislators and executives involved, it will probably not make a significant contribution to informing the collective decisions or management actions. This is widely understood, and many efforts are beginning to be made to find model structures which facilitate communication between information -- or models and procedures -- and resource managers.

Clearly, success is not limited to systems which satisfy the check list of factors in a 'model' information system. The technical sophistication of methodologies cannot, in itself, guarantee the continued use of a system. But it can serve to counteract utility. System survival has been shown to depend less on the concrete, and more on the qualitative and political aspects of its development.

The conceptual framework reflects this observation. The manner and degree to which the criteria in this framework are met, will have a decisive effect upon the achievement of technical goals. The acheivement of technical goals is inherent in the capability to optimize the generation and use of specific information for decision-making purposes. Most importantly, the conceptual framework determines the interfaces and interfacing mechanisms which are crucial to accomplishing information transfers of this kind.

The importance of the conceptual framework to information systems and their interfaces, bears repeating it in the summary.

CONCEPTUAL FRAMEWORK

1. Involve the user from the beginning and maintain user involvement with the objective of reaching consensus on all aspects of the system

2. Design the system to fit directly into the legal/administrative framework

3. Establish system credibility

4. The system design should be flexible and future-oriented

5. The system must emphasize cost-effectiveness

Applying the conceptual framework to developing an information system, requires identifying, establishing, and maintaining appropriate interfaces. Effective interfacing mechanisms[152] have proven to be user training programs, coupled with formal arrangements to accept, evaluate, and act on user-feedback. The most effective means, however, is to maintain user-involvement throughout development, to the extent that the user and contracting organization are co-developers of the system. 'Promising' interfacing mechanisms include the early designation of user-advocates, and the adherence to a systematic consensus-reaching technique. Both of these would greatly facilitate defining informational needs, in addition to selecting an appropriate system design.

While efficiency in developing an information system may be a prime objective, or even a constraint imposed by fiscal schedules, it should not be pursued at the expense of: 1) user-involvement in all activities, or 2) a systematic approach to deciding on design and implementation strategies. These two factors can lead to efficiency during ensuing stages, where it matters most. For example, during the implementation of a system, the aim is to curb the number of interruptions required to tailor the system to the user. The latter activity should be carried out from the beginning, through the procedures mentioned above. The failure to demonstrate the credibility of a system at every step in its development, may lead to its rejection by intended users. Educating the user and incorporating user feedback throughout the development process, are prime responsibilities of system developers.

Hence, provisions for establishing the necessary interfaces must be made early -- during pre-proposal exchanges, when possible. Likewise, efficiency in operation should be a goal planned for from the outset, as it is frequently a measure of a system's overall utility. Here, response time, flexibility, and cost are of foremost concern to potential users. A politically stable environment has also been shown to be crucial to the achievement of continued user support.

The results of the present study provide further insight into the complex question: 'What factors are most likely to bring about the continued use of an information system.' While interfacing plays an important role in effecting system utility, the motivation to maintain these interfaces and to use them constructively, is equally as important. The motivation problem is, necessarily, two-sided. For instance, developers must try harder to communicate the technical capabilities of a system in terms that are understandable to environmental managers. Similarly, managers must begin to appreciate how an appropriate information system might help them to carry out their management responsibilities. They must particularly be open-minded to the possibility of employing computerized informational tools. Finally, the motivation to keep a system cost-effective, must be balanced by a willingness to allocate the appropriate funding to make the effort pay off.

Strome and Lauer discussed problems of motivation associated with the transfer of remote sensing technology: "Before any attempt can be made to transfer a new technology to a prospective user, he must be motivated to accept it."[153] The difficulty of this task surpasses that of inducing effective communication. Motivating end-users is the key to securing active user-involvement in the system development process. It also explains why in-house efforts, and efforts tied into the administrative framework, generally realize the greatest long-term success. The motivation originates with the user. It is not fabricated through the seductive sales pitch of a potential developer. It is evident that the motivation problem is an enigma worthy of a thesis in itself, and cannot, therefore, be adequately addressed here.

Finally, it follows that the system developer bears the risk of failure, if development is carried out without sufficient attention to the conceptual guidelines outlined above. Potential users share this responsibility once their role in the development process has been conveyed. Application of this framewcrk to existing systems may also help to detect problem areas in time to prevent their occurrence. Implicit in averting potential problems are the human interfaces that must be established and maintained. These interfaces are requisite, not only to deciding on appropriate courses of action, but to executing such steps as smoothly as possible.

NOTES

[1]See Lauriston R. King, "The International Decades of Ocean Exploration Program in Marine Science Affairs," MIS Journal 11 (December 1977): 14; P. G. Rowe, J. L. Gervirtz, and P. Weichert, "A Natural Environmental Information and Impact Assessment System," Transactions, 27th Annual Meeting, Gulf Coast Association of Geological Societies (October 1977), p. 158 (hereafter cited as Rowe et al., "Assessment System"); Thomas S. Austin, "Challenges for Meeting Public Needs for Science Information," Environmental Data Service (November 1977):3; and Robert H. Ellis et al., "The Design of a Management Information System for Coastal Resources Planning," prepared for the Regional Marine Resources Council, Nassau-Suffolk Regional Planning Board, (Hartford, CT.: Center for the Environment and Man, Inc., February 1972), p. 1 (hereafter cited as Ellis et al., "MIS").

[2]W. M. Strome and D. T. Lauer, "An Overview of Remote Sensing Technology Transfer in Canada and the United States," in Proceedings of the Eleventh International Symposium on Remote Sensing of the Environment (Michigan: University of Michigan, 1977), vol. 11, no. 1, p. 325.

See also Donald B. Straus, "Mediating Environmental, Energy and Economic Trade-Offs: A Case Study of the Search for Improved Tools for Facilitating the Process," paper presented at the AAAS Symposium on Environmental Mediation Cases, Denver, Colorado, 20-25 February 1977 (hereafter cited as Straus, "Mediating Trade-Offs"); and statement by Jens Sorensen, Sea Grant, University of California, at the "Workshop on Information Systems for Coastal Zone Management," sponsored by Environmental Data and Information Service and Center for Ocean Management Studies, University of Rhode Island (Exeter, Rhode Island: 22-23 June [1978]). (Typewritten notes). (Hereafter cited as "Workshop").

[3]Tschanz and Kennedy, in Natural Resource Management Information Systems: A Guide to Design (Argonne, Ill: Argonne National Laboratory, 1975), p. 26 (hereafter cited as Tschanz and Kennedy, Guide), define an information system as "an ordered combination of data bases, resources (staff, material, building, equipment, etc.), and procedures designed to produce information useful to the decision-making process." They further indicate that the amount of computerization is irrelevant to this classification.

[4]South Carolina Wildlife and Marine Resources Department, "Coastal Plains Regional Resource Information System Study," submitted to the Coastal Plains Regional Commission (January 1978), p. 6 (hereafter cited as S.C. Coastal Plains Study).

[5]Systems which receive little or no use include:

Marine Information System (MIS)

Intuitive Interactive Model (IIM)

Classified and Organized Verbal Information Retrieval System (COVIRS)

Environmental Information Retrieval System (ENVIR)

[6]Interfaces can be persons or procedures which "link the information system to its user community, sources of data, and developers of information system technology." Tschanz and Kennedy, Guide, p.2.

[7]Such interfaces are specific to computerized information systems. The mechanism is special software which permits varying degrees of interaction between the user and the procedures being performed. A number of systems have built-in "prompt" or "query" modes (discussed later) to guide nontechnical users through selected data processing operations. These modes, which employ simple, english language instructions throughout the exercise, can be bypassed in certain systems by experienced users who want to streamline their analyses. See California Coastal Commission, "Comparison of Information Systems" (San Fransisco: California Coastal Commission, [1977]). (Incomplete draft report.) (Hereafter cited as Calif. Coastal Study); S.C. Coastal Plains Study, p.6; and Joseph M. Heikoff, Coastal Resources Management: Institutions and Programs (Ann Arbor, Mich: Ann Arbor Science Publishers, Inc., 1977).

[8]Sources included promotional literature and publications, conversations with developers and users, the two-day "Workshop on Information Systems for Coastal Zone Management" (22-23 June 1978), and other comparative studies. Although the partiality of such information would be implicit in the sources consulted, its use was justified on the presumption that potential users (and funders) would, likewise, derive expectations from a similar, if not the exact, set of descriptions.

[9]Continued use of an information system is a widely accepted measure of its success. International Geographical Union, Computer Handling of Geographical Data, a report by the Commission on the Geographical Data Sensing and Processing of the International Geographical Union with the cooperation of UNESCO and governmental agencies in Canada and the United States (France: UNESCO Press, 1976), p. 17 (hereafter cited as IGU Study).

[10]Calif. Coastal Study, Section II.C.1.a.

[11]The Department of Ocean Engineering at the University of Rhode Island, in conjunction with the state Coastal Resources Center (CRC), Coastal Resources Management Council (CRMC) and the Department of Environmental Management (DEM), initiated the development of an interactive, graphic-display Coastal Zone Information System. It was primarily to be used by the CRMC in support of their management program. Both the DEM and CRC were target users as well. A permit application information component and an oil spill model for Narragansett Bay have been completed. However, both await implementation and use. The CRMC has experienced difficulty maintaining direct and continued involvement throughout the development of these components. This ultimately reflects the unrest within their own political and administrative spheres. Until these areas are resolved, such that management procedures and responsibilities are more clearly defined, the CRMC may not be fully motivated to support the information system.

The IIM was partially the result of data validation techniques introduced by the American Arbitration Association (AAA) and the development of different impact prediction scenarios keyed to the (developing) management program and permit requirements. The system was designed for and tested on one community, Dover Township. Though it received strong public and administrative support, no single agency would commit the necessary resources to keep it operational. This was largely due to the volatile political situation at the time. (Interview with M. Greenberg, Division of Urban Studies, Rutgers University, New Brunswick, New Jersey, 5 July 1977; and M. Greenberg, letter to McCreary, Californaia Coastal Commission, September 1977.)

It has since been replaced by the Coastal Location Acceptibility Method ("CLAM"), developed by the New Jersey OCZM. "CLAM" was designed to specifically fit into the permit review process of the coastal management program. See New Jersey Department of Environmental Protection, "New Jersey Coastal Management Program - Bay and Ocean Shore Segment and Draft Environmental Impact Statement" (Trenton: Division of Marine Services, OCZM, May 1978), pp. 21-23 (hereafter cited as N.J. CMP); and Wiener, interview. See also Appendix B.)

[12]These primarily fall under the National Oceanic and Atmospheric Administration's (NOAA) Environmental Data and Information Service (EDIS) and Office of Sea Grant. Examples include: the Oceanic and Atmospheric Science Information Service (OASIS); the Environmental Data Index (ENDEX); Regional Coastal Information Centers (RCICs); Regional Marine Advisory Service (MAS) programs; also the Outer Continental Shelf Referral Center of the Department of the Interior.

[13]ENVIR is now maintained and operated (though infrequently) by the Marine Science Institute Laboratory of the University of Texas. Plans for its application toward land-use management are in the making. Interview with Carl Oppenheimer, Marine Institute Laboratory, University of Texas, 11 August 1978.

[14]Systems having state coverage or special purpose functions, such as coastal or land-use management, may, as one of their objectives, be 'transferable' to other areas or may eventually serve larger regions. One distinction between the large and small-scale systems, therefore, is the mandatory versus optional requirement, respectively, for a transferable design. [An exception would be the small-scale systems which support developing management programs. Informational requirements differ sharply between the policy-formation and later resources management stages.] Tschanz and Kennedy, Guide, p. 18.

[15]IGU Study, p. 24.

[16]Tschanz and Kennedy (Guide, p. 25) distinguish 'information' from 'data' on the basis of its usefulness in decision-making. 'Data' is transformed into 'information' the moment it is applied to resource management decisions. Also, data generally implies 'manipulated' data.

[17]See S.C. Coastal Plains Study; and Tschanz and Kennedy, Guide.

[18]All states have some type of management and regulatory programs for pollution control through federal laws. These include:

- National Environmental Policy Act of 1969 *
- Clean Air Act Amendments of 1970 *
- Federal Water Pollution Control Act Amendments of 1972

In addition, state programs have been generated by:

- Coastal Zone Management Act of 1972 *
- National Flood Insurance Act of 1968
- Wild and Scenic Rivers Act of 1968 *
- Interstate Land Sales Full Disclosure Act of 1969
- Federal Housing Act (HUD) of 1954, Section 701

* These federal actions specifically mandate that relevant information be provided and used to make wise decisions regarding development activities. See Tschanz and Kennedy, Guide; and S.C. Coastal Plains Study, p.2.

It was estimated that more then 130 federal programs relate to land use alone, in the Coastal Plains Study (p. 28).

Also, a recent federal policy -- the National Science, Engineering, and Technology Policy and Priorities Act of 1976 (PL94-282) -- requires "effective management of scientific and technical information..." and the incorporation of "scientific and techinincal knowledge in the national decision-making process." While the Act places specific responsibility on the federal government to "promote prompt, effective, reliable, and systematic transfer of scientific and technological information...", it would, necessarily, apply to other governmental and non-governmental sectors committed to science and technology, as well. See Austin "Challenges," pp. 5-6.

[19]S.C. Coastal Plains Study, p. 28.

[20]Tschanz and Kennedy, Guide.

[21]There is common agreement as to the basic elements of an information system. The delineation is as follows:

- data acquisition
- data input and storage
- data retrieval
- data processing and analysis
- information output

A 'management function' is considered an essential part by a few. See Tschanz and Kennedy, Guide; and IGU Study. See also Appendix A and Table 9.

Further, information systems are typically distinguished by the following:

1. functional orientation: e.g; geographic, non-geographic (S.C. Coastal Plains Study)
2. area covered: e.g; county, state, region, country, coastal zone, single site (Tschanz and Kennedy, Guide)
3. user community: e.g; institution; local, state or federal agency (Schneidewind, "Information Systems and Data Requirements: Coastal Development Planning," in Brahtz (ed.), Ocean Engineering, Goals, Environment, Technology (New York: Wiley, 1968), p. 229 (hereafter cited as Schneidewind, "Data Requirements"); and Austin, "Challenges," p. 5.)

[22]See Tschanz and Kennedy, (Guide), pp. 16,18; and Schneidewind, "Data Requirements", p. 224.

[23]Lowe and Moryadas define 'utility' as "the capacity of a commodity or a service to satisfy some human want."

They further distinguish between time utility and place utility, in proposing that the movement of information (or goods, etc.) is purposeful. (Lowe and Moryadas, The Geography of Movement (Boston: Houghton Mifflin Co., 1975.) The movement of information via information systems has, as prime incentives, the spatial and temporal separation of people and particular information. In fact, a common gauge of a system's performance has been its response time. See Calif. Coastal Study, p.8; and IGU Study, chap. 3.

[24]"Workshop," June 1978.

[25]The importance of reaching a consensus is stressed in Section IV.

[26]Stated by A. Robinette and P. Templet, respectively, at the "Workshop".

[27]The IGU Study (p. 21) warns that without the "closest management and supervision possible," outside developers "may produce what they think is required rather than what is needed by the system."

[28]The MIS was designed to support a planning and management program for Long Island Sound. It was partially funded by the Sea Grant Program. The MIS was never implemented despite nearly five years of comprehensive planning.

[29]Ellis et al., "MIS" (1972); and interview with L. Koppleman, Regional Marine Resources Council, Nassau-Suffolk Regional Planning Board, 13 July 1977.

The MIS subcontractors explicitly stated in their report on knowledge requirements:

> "It must be emphasized that the knowlegde requirements listed here, if fully satisfied, would provide perfect information for the planning and management of Long Island's marine resources. This ideal, of course, is not feasible from a technical standpoint. Nor is it likely to be feasible from an economic standpoint..."

See P. Cheney, "The Development of a Procedure and Knowledge Requirements for Marine Resource Planning, Functional Step Two, Knowledge Requirements" (Hartford, CT: Travelers Research Corp., February 1970), p. 17.

In a subsequent report, the contractors had isolated several coastal management problems "which in our judgement are high priority." [Underscore theirs.] P. Cheney, "High Priority Research and Data Needs, Interim Functional Step Four" (Hartford, CT: Travelers Research Corp., November 1970), p. 4.

[30]S.C. Coastal Plains Study, p.3.

[31]Interview with Saul Wiener, Sr. Landscape Architect-Planning Coordinatcr, New Jersey Office of Coastal Zone Management, in charge of "CLAM", 21 August 1978.

[32]The matter of 'system flexibility', to enable it to adapt with its management program, to changes in administrative responsibilities, is addressed later.

[33]See n. 11 for a discussion of the IIM. The Regional Planning Board, for which the MIS was drawn up, implemented their own system which was better suited to their immediate needs. Importantly, the MIS was directed toward planners in general, rather than to the Planning Board, specifically. Ellis et al., "MIS", (1972); Koppleman, interview: see also n. 28 above.

[34]The California Coastal Study (p. 18) referred to the IIM as "one of the most forward looking systems."

Although the MIS gave every indication of providing both valid and thorough technical capabilities (through the complexity of its design), the feasibility of implementation, as recognized by the intended user-agency as well as its developers, was highly doubtful and economically impractical. See n. 29 above.

[35]The Washington Shorelines Management Act of 1971 mandates a good data base and skillful methodologies for "meshing the data and legislation" into coastal planning and management decisions. (Calif. Coastal Study).

The MLMIS is not authorized by state law, though the Department of Administration (DOA) has had legal responsibility to maintain an inventory of state-owned land since 1938. The system exists as a result of combined efforts by the State Planning Agency (SPA), the Center for Urban and Regional Affairs (CURA) of the University of Minnesota, and the DOA. Biennial funding also comes from the Minnesota Resources Commission. (IGU Study, chap. 6.)

Louisiana's "Information System" is, like the MLMIS, grounded in the organizational framework and not in specific legislation. The impetus for continuation comes from a semi-technical advisory group comprised of representatives from 17 local governments which are contracted to develop their own coastal management plans. (Paul H. Templet, "Discussion of Louisiana's "Information System"," presented at the Workshop on Information Systems for Coastal Zone Management, sponsored by the EDIS and the Center for Ocean Management Studies of the University of Rhode Island, 22-23 June 1978) (hereafter cited as Templet, "La.'s Information System".)

[36]The technical disadvantages in all three systems stem from their emphasis on map generation. Although maps are considered an effective means of information transfer, most

criticisms relate to the inflexibility of such products. (Tschanz and Kennedy, Guide, p. 31.) Common problems inherent in mapped data, include the loss of original data through compression, their inability to adapt to changes in information needs (due to legislation or new management issues), and the impracticality of updating the information. ("Workshop" discussions.)

Certain aspects of each system -- such as the extreme budget requirements of the Washington Atlas (including several interactive modules); the inconclusive nature of the MLMIS models, plus the lack of an overall system design and a limited number of variables (two) which must be analyzed by the user; and the pending legislative changes with Louisiana's developing coastal management program -- would be fatal in the context of any other respective organizational environments. See "Workshop"; IGU Study, p. 108; and Templet, "La.'s Information System".

[37]The California Coastal Study (p. 18) pointed out that while the perceived need for specific types of information may be well founded, "it is equally as important that there be a common methodology for applying the data to coastal planning issues."

[38]The importance of early user identification was emphasized throughout the Information Systems Workshop (June 1978), as well as by Tschanz and Kennedy (Guide, p.57), and investigators for the IGU Study.

According to the Lane Council of Oregon Governments (LCOG), the single most important reason for the success of their Map/Model System, has been the Council's direct and continuous involvement in the development process. The system currently receives continued support from the LCOG and two additional primary users -- the Bureau of Land Management and the State Department of Forestry -- both of which became involved at the outset of an effort to expand the Map/Model programs to suit their specific needs. See Calif. Coastal Study, pp. 9-12.

[39]ENVIR, a commercial offshoot of EDMPAS, has been dormant for six months and relatively inactive for a year and a half (as of August 1978). Oppenheimer, interview.

COVIRS serves unlimited user types on an international scale, and makes available legal and other decisional data pertaining to environmental matters. The system is only occasionally used due to the lack of funding plus the decision not to market it. Statements by Dennis O'Connor, Ocean Law Program, University of Miami, at the "Workshop".

UPGRADE, (User-Prompted GRAphic Data Evaluation), is a federally maintained system (CEQ) with remote terminal access. It will also serve at the state level when completely operational. Based on preliminary experimentation by the New Jersey OCZM, in conjunction with their "CLAM" system, the outlook for wide useage of UPGRADE in state programs appears dim at the present. Wiener, interview.

Other drawbacks stem from its use of federally collected statistics which, characteristically, are of unsure quality. Statements by John Buffington, Council on Environmental Quality, Washington, D.C., at the "Workshop"; IGI Study, p. 23; and Scheidewind, "Data Requirements," p. 230.

[40]Although the MLMIS was developed within the state-level organizational framework, the failure to identify a specific user-organization at the beginning, is now manifest in its infrequent use. (It was intended for state and local government decision-makers, in general.) See Tschanz and Kennedy, Guide, p. 34; see also n. 35 above.

Both Tschanz and Kennedy (Guide, p. 34) and the IGU Study (p. 106), in reference to the MLMIS, noted that "As with almost any system, the actual identity of potential users is somewhat obscure." However, as mentioned earlier, the strong administrative foundation of MLMIS should overcome the obstacles presented by the lack of clearly defined needs (see n. 35 above), and a target user, plus certain technical limitations (see n. 36 above). Use of MLMIS should be sustained, though at less than optimal levels.

The extreme consequences of neglecting to identify and involve a particular user, during the pre-proposal stage of an information system, are seen in both the IIM and the MIS (see n. 33 above).

[41]See IGU Study; E.E. Hardy, "Inventorying New York's Land Use and Natural Resources," Food and Life Sciences Quarterly 3 (October - November 1970); also, interview with G. Cook, Director of Genessee Finger Lakes Regional Council, Rochester, New York, 15 August 1978.

[42]This does not mean, however, that an interdisciplinary approach to identifying priority needs is necessarily detrimental to the end product. In fact, an interdisciplinary view of resource management problems is recommended -- but as an aid to the user-agency in assessing and ranking its particular informational needs.

[43]See notes 39 and 40 above.

[44]Tschanz and Kennedy, Guide, p. 29.

[45]IGU Study, p. 20.

[46]See n. 37 above.

[47]Calif. Coastal Study, p. 9.

[48]Ibid, pp. OM - 9-12. See also n. 38 above.

[49]IGU Study, chap. 3.

[50]That there is a common distrust of computers and computer technology by environmental administrators is widely recognized. (Straus, "Mediating Trade-Offs"; "Workshop"; IGU Study, chap. 3: and S.C. Coastal Plains Study.) Developers have adopted various approaches to dealing with this problem and-- since it is ultimately a question of communication, or <u>interfacing</u> -- have achieved the best results by working directly with the user-agency from the start, and by carefully documenting all procedures. (This is discussed further in the next sections.)

[51]With some outside advising at most, the systems listed below were developed (or are being developed) by the eventual principle user. All are considered 'promising', if not already successful. Those systems which began as joint efforts and have acheived operational success -- LUNR, Oregon's Map/Model, MLMIS, Washington's Coastal Zone Atlas, and most systems tied into university computer facilities, (e.g; EDMAS, North Carolina Planning and Management System (PLUM)*, and the University of Virginia Coastal Information System (UVAIS)**) -- are not considered here due to their impled interfacing needs. The following examples reflect efforts which did not require user/developer interfaces, since these denominations were essentially one and the same. Interestingly, examples of unsuccessful (e.g; discontinued) systems of this nature are unknown.

Systems developed by their users include:

Louisiana's "Information System"

Marine Environment And Resources Research and Management Information System (MERRMS)

New Jersey's "Coastal Location Acceptability Method" ("CLAM")

Washington Department of Ecology's "Shoreline Management [Permit Inventory] System"

Nassau-Suffolk Regional Planning Board's "Information System"

*** Oak Ridge Regional Modelling Information System (ORRMIS)

* PLUM was initially developed by the North Carolina State University, Department of Computer Sciences for the North Carolina Land Policy Council. S.C. Coastal Plains Study, pp. 128-129.

** UVAIS is under development by the University of Virginia for Navy, through ONR support. C. Rea, "UVAIS - The University of Virginia Coastal Information System: A Data and Model Index Designed for the Office of Naval Research, Geography Programs," presented at the Workshop on Information Systems for Coastal Zone Management, sponsored by EDIS and the Center for Ocean Management Studies, University of Rhode Island, Exeter, Rhode Island, 22-23 June 1978.

*** ORRMIS was developed by and for the Oak Ridge National Laboratory, through its National Science Foundation environmental program, and in conjunction with its Regional Environmental Systems Analysis (RESA) research project (now extinct). The system is occasionally applied to regional and local planning problems, though its design is specific to the Laboratory. Scientific expertise is required for proper use. Interview with R. Durfee, Computer Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 22 August 1978. See also IGU Study, chap. 8.

[52]Examples of systems that have realized favorable funding environments include:

Washington Coastal Zone Atlas

Minnesota Land Management Information System (MLMIS)

Oregon's Map/Model

* Environmental Management Decision Assistance System (EMDAS)

** North Carolina Planning and Management System (PLUM)

** South Carolina Computerized Land Use Information System (CLUIS)

*** University of Virginia Information System (UVAIS)

* Developed by the Southwest Center for Urban Research

and the Rice Center for Community Design and Research, for decision-makers in Chambers County, Texas, through an NSF grant.

** S.C. Coastal Plains Study; see also n. 51 above.

*** See n. 51 above.

[53]Examples of less successful, or perhaps untimely systems, include:

Marine Information System (MIS)

Intuitive Interactive Model (IIM)

* "Scorecard"

* An automated permit inventory system developed for the South Coast Regional Commission under a contract to the USC Sea Grant Program. According to the director of Sea Grant's Marine Advisory Service, the system was operational from February 1973 to May 1975. The software was developed "exactly as contracted", but the output was too complex for the Commission to handle. Another possible reason suggested for the discontinuance of "Scorecard" was its unanticipated role in 'monitoring' the activities of the Commission, often revealing major inconsistencies. Interview with L. Leopold, Director, M.A.S., U.S.C. Sea Grant Program, Wilmington, California, 3 August 1978.

[54]See Tschanz and Kennedy, Guide; IGU Study: Calif. Coastal Study; and "Workshop".

[55]IGU Study, chap. 3.

[56]These problems are addressed in Section V.

[57]This problem relates the importance of fitting the information system into the administrative framework. See Templet, "La.'s Information System"; and Calif. Coastal Study.

[58]This problem may become a major obstacle during implementation. User involvement from the beginning greatly facilitates this transfer, but is most effective when specific user-delegates follow through with the entire

development effort. [While the decision to employ "user-advocates" should be made at the outset, actual designations may be made later, if in-house staff are available. This is also addressed in later sections.] See IGU Study; "Workshop"; Tschanz and Kennedy, Guide; Rowe et al., "Assessment System", p. 162.

[59]See Templet, "La.'s Information System"; Calif. Coastal Study; Tschanz and Kennedy, Guide, p.60; and "Workshop".

[60]IGU Study, p.21.

[61]Russell and Kneese, "Establishing the Scientific, Technical, and Economic Basis for Coastal Zone Management," CZM Jour., vol. 1, no. 1 (1973): 62-63.

[62]See n. 57 above.

[63]Russell and Kneese, "Establishing the Basis for Coastal Zone Management," pp. 62-63.

[64]See n. 58 above.

[65]Outcomes of the following university-affiliated systems have been favorable:

Washington's Coastal Zone Atlas

Environmental Management Decision Assistance System (EMDAS)

University of Virginia Information System (UVAIS)

* Marine Environment and Resources Research and Management Information System (MERRMS)

While less successful results distinguish the systems below:

Intuitive Interactive Model (IIM)

Classified and Organized Verbal Information Retrieval System (COVIRS)

Environmental Information Retrieval System (ENVIR)

* Although MERRMS now serves a wide user-audience, including state and local managers, it was originally intended for university use, with only indirect benefits to management agencies. See n. 41 above.

[66]See Schneidewind, "Data Requirements", p. 230;

statement by J. Pleasants, Virginia Institute of Marine Science, Gloucester Point, Virginia, at the "Workshop"; and S.C. Coastal Plains Study, chap. 3.

[67]See notes 36, 39, and 46 above.

[68]See Tschanz and Kennedy, Guide, p. 80; and "Workshop". (Discussed further in Section IV.)

[69]The RAEG System (Rapid Access to Environmental Guidance) is one of many proposed efforts that proved too cost ineffective to develop. This system was the result of a contract, between the Conservation Foundation and a consulting firm, to formulate a method for computerizing information collected during OCS studies. The Fish and Wildlife Service wanted to use it in processing permits and assessing environmental impacts. Teknekron, Inc., "System Description of the Proposed RAEG System (Rapid Access to Environmental Guidance)", excerpted from Teknekron Phase II Report to the Conservation Foundation, Washington, D.C. (1976); also, interview with Conservation Foundation, Washington, D.C., 9 August 1978.

[70]Interviews with: A. Edwards, New York Office of Planning Services, Albany, New York, 15 August 1978; R. Crowder, N.Y. OPS, Economic Development Board, 8 September 1978; and G. Cook, Gennessee Finger Lakes Regional Council, 15 August 1978. See also, IGU Study, p. 123.

[71]The Critical Resources Information Program, originally proposed to aid state resources planning, was modified considerably due to two primary factors: 1) the lack of funds - (one anticipated source was the Federal Land Use Bill, which never passed), and 2) extreme public interest in the citizen's identification of critical areas component. The system, now called the Heritage Areas Program, has been operating since 1973 out of the University of Wisconsin. But it is 'sustained' on unstable funds acquired through random sources. Interview with B.J. Niemann, Department of Landscape Architecture, University of Wisconsin, 8 September 1978.

[72]A case in point is the South Coast Regional Commission's "Scorecard", (California). (See n. 53 above.) Other systems, such as the proposed RAEG and CRIP, illustrate how the inability to reach a consensus on an initial conceptual design can, in itself, help to redefine real needs and save the costs of producing an unserviceable product. (See notes 69 and 71 above.)

[73]From: Tschanz and Kennedy, Guide; IGU Study; Ellis et al., "MIS" (1972); and "Workshop".

[74]Rowe et al., "An Environmental Management Decision Assistance System for Local Governments," in Proceedings, 15th Annual Conference, Urban and Regional Information Association, August 1977, p. 161 (hereafter cited as Rowe et al., "Local Governments").

[75]This study encompassed five southeastern coastal states: Georgia, North Carolina, South Carolina, Virginia, and Florida. S.C. Coastal Plains Study. See also Appendix A.

[76]S.C. Coastal Plains Study, p.6.

[77]Rowe et al., "Local Governments", p. 161.

[78]Weinberg defines a 'system' as "a set of objects together with relationships between the objects and between their attributes," but more importantly, these objects are arranged to show a plan. Weinberg, G.M., "An Introduction to General Systems Thinking" (New York: John Wiley & Sons, inc., 1975), p. 63.

[79]Acceptance of a system's 'honesty' is crucial to establishing the credibility of the system (addressed later) and hence, to instilling confidence in the user.

[80]The infrequent use of large-scale and commercial systems by state and local managers, demonstrates the extreme consequences of virtual 'black box' development. The developers of New Jersey's "CLAM", after about a year of testing, have yet to determine how to use UPGRADE procedures effectively, much less how they can assist the current management program (see n. 39 above).

[81]See Section III. C.

[82]Strome and Lauer, "An Overview"; and Rowe et al., "Assessment System", p. 162.

[83]See n. 58 above.

[84]Technicians are appointed, often from within the contracting organization, when an agency will not assume direct responsibility for managing or operating the system once it is implemented.

[85]IGU Study, p. 20.

[86]Only the Rhode Island Coastal Zone Management System appears to have experimented with the notion of a "user-advocate" during design and development efforts -- though with some difficulty securing a steady correspondent. This can be attributed to general staffing difficulties as

well as unstable political conditions. (See Section III.C and n. 11.) Other systems have employed similar interfacing mechanisms during implementation and operation procedures. These are discussed in the next section.

[87]Both immediate and future needs must be identified, to the extent possible, as these will determine the amount of flexibility which must be built into the system. (Design flexibility is discussed later.)

[88]These consensus-reaching approaches to design methodologies and development activities would be of particular value to systems assembled incrementally, over long periods (the modular approach).

[89]Straus coins this the 'chicken and egg dilemma' which also, accounts for the reluctance of most managers to endorse the use of computerized information systems. While interest in new procedures is easily generated, the aversion to experimenting with them to prove their credibility, stems from:

1. the lack of an effective means of communication -- e.g; a general language barrier
2. the unpredictability of the outcome -- e.g; a general avoidance of risking time, money, and bargaining power
3. too much unnecessary information and not enough problem-oriented information to consider

Straus, "Mediating Trade-Offs", pp. 22-23.

[90]See notes 28, 29 and 33 above.

[91]Tschanz and Kennedy, Guide, p. 85; see also, Appendix B. Though no guidelines were presented, the IGU study group also strongly recommended the adoption of an approach of this nature. IGU Study, chap. 3.

[92]Problems in applying output from the land planning simulation models contained in MLMIS, to specific issues, were the consequences of the failure to reach a consensus on the models beforehand. The lack of a clearly defined end-user from the outset may have contributed to the status of the models, as well. Statement by A. Robinette at the "Workshop"; see also n. 40 above.

[93]Rowe et al., "Assessment System", p. 161.

[94]A. MacBeth, "Modeling in the Context of the Law," in C. Hall and J. Day, Jr. (eds.), Ecosystem Modeling in Theory and Practice: An Introduction with Case Histories (New York: John Wiley & Sons, 1977), p. 203 (hereafter cited as MacBeth, "Modeling").

[95]See IGU Study, chap. 3; A. MacBeth, "Modeling"; and "Workshop".

[96]LUNR also has several computer capabilities. But one in particular, PLANMAP II, has received little use. The IGU Study (p. 121) suggests, "This is mainly due to difficulty of use, and also to general unfamiliarity with its potential."

[97]See n. 7 above.

[98]SEEDIS was developed for ERDA and the Bureau of the Census, by the Computer Science and Applied Mathematics Department of the Lawrence Berkeley Laboratory, California

[99]From: Tschanz and Kennedy, Guide; IGU Study; Straus, "Mediating Trade-Offs"; and "Workshop".

[100]EMDAS is distinct in providing the end capability of generating impact assessment reports in prose format.

[101]See n. 51 above.

[102]Rowe et al. ("Assessment System", p. 161) note that building intelligibility into interactive computer interfaces requires a high level of internal structure. But this facilitates "leading a user step-by-step through the evaluation procedure," thus allowing the methodology to be understood. There is obviously a certain trade-off here -- involving the degree of structure permitted by the time and budget constraints in force -- which must be balanced at the outset of the project.

[103]The output from California's "Scorecard" system typifies this situation (see n. 53 above), as do some MLMIS maps (see notes 36 and 92 above). See also, Calif. Coastal Study, Section II. C.

[104]It is assumed (at this point) that agreement on system products has occurred, and that these were oriented to specified problems.

[105]See n. 16 above.

[106]Calif. Coastal Study, p. 18.

[107]The game of "what if" entails "developing new bundles of proposed actions, impacts, benefits, and costs in the effort to discover one or more that will be acceptable." See Straus, "Mediating Trade-Offs", pp. 2,9; and "Workshop". See also, Appendix B.

[108]See IGU Study; "Workshop"; MacBeth, "Modeling", p.

203; Straus, "Mediating Trade-Offs"; Rowe et al., "Assessment System", p. 161; and Calif. Coastal Study.

[109]See n. 89 above.

[110]See IGU Study; "Workshop"; MacBeth, "Modeling", p. 203; Straus, "Mediating Trade-Offs"; Rowe et al., "Assessment System", p. 161; and Calif. Coastal Study.

[111]M. Rosenfeld, "Marine Data Management - The Views of University Scientists," in Marine Technology Society, Proceedings: International Marine Information Symposium, 1968, 31 October - 1 November, p. 105.

[112]Schneidewind, "Data Requirements", pp. 222-223.

[113]Special regard to data validation and/or documentation of steps is demonstrated in the following systems:

LUNR

* EMDAS

Washington Coastal Zone Atlas

ORRMIS

UVAIS

* In developing EMDAS, Rowe et al. ("Assessment System") noted that the approach to system design must be chosen relative to the level of accuracy in the desired information. But, even when greater resolution may be required, the need to limit the structure of the system may mean sacrificing some reliability and validity of results.

[114]UPGRADE has the added burden of having to overcome the bias frequently attached to using agency-collected information. See n. 39 above, and Section III.C.

[115]The need for careful data screening has been repeatedly stressed. The purpose is to avoid: 1) having to handle enormous amounts of unnecessary data, and 2) "clouding issues" with extraneous information. See Calif. Coastal Study; Tschanz and Kennedy, Guide; IGU Study; and "Workshop". See also n. 89 above. On how to collect data, R. Daugherty rightly advises, "What ever the methods chosen, they must be seen as subservient to the problem." R. Daugherty, Science in Geography 2: Data Collection (London: Oxford University Press, 1974), p. 9.

[116]See Straus, "Mediating Trade-Offs"; MacBeth, "Modeling"; Rowe et al., "Assessment System"; and "Workshop".

[117]Despite careful sensitivity testing -- which A. MacBeth ("Modeling", p. 203) states "is extremely helpful in making clear to the audience the importance of particular assumptions and identifying the crucial leverage points in the system being analyzed" -- the IIM succumbed to the political fault of not being securely tied into the adminstrative framework (see n. 33 above). MLMIS models, conversely, were strongly criticized for the confusion in applying them to specific problems. The system is infrequently used -- but ongoing, nonetheless (see notes 40 and 92 above).

[118]Lillesand and Tyson, "Addressing the Remote Sensing 'Data-Information Gap': Overhead Monitoring in New York's St. Lawrence River - Eastern Lake Ontario Coastal Zone," in _Proceedings of the Tenth International Symposium on Remote Sensing of the Environment,_ Environmental Research Institute of Michigan, University of Michigan, 1975, p. 191.

[119]The output from MLMIS models, for example (see notes 40 and 92 above).

[120]The state's need for greater resolution than provided in LUNR overlays led, in part, to the decision not to update the system (see n. 70 above).

[121]See n. 36 above.

[122]This was the precise reason for adopting maps as the prime output in Louisiana's "Information System". (Templet, "La.'s Information System".) Also influential, would be the emerging trend toward computerizing spatial data and providing software to allow users to generate maps to (virtually) their own specifications. This approach is beginning to supplement 'atlas-producing' systems, such as the Washington Coastal Zone Atlas and MLMIS, because it does not lock systems into a product that will be useful for only a short time. One advantage is that data bases may be updated to keep the output current.

[123]Adopting standard geographic referencing systems and scales seems to be an initial stumbling block common to many systems. Proceeding without consensus on the choices, or without knowledge of future management directions, can render the system inflexible if the choices are less accurate than later informational needs would require. (See n. 69 for a discussion of LUNR.) Not reaching consensus on MLMIS models cost this system some flexibility, also (see notes 36 and 92).

[124]See n. 21 above.

[125]See Tschanz and Kennedy, Guide, p. 75; and Ellis et al., "MIS", p. 4.

[126]Ibid.

[127]See n. 36.

[128]Several national awards are indicative of the 'success' of the Washington Coastal Zone Atlas -- or at least of its cartographic procedures -- as is the ongoing use of LUNR to its 'success', (in spite of not having been updated since 1975). Interview with M. Rundlett, Department of Ecology, Olympia, Washington; Crowder, interview; and statement by C. Youngman, Cartographic Laboratory, University of Washington, at the "Workshop".

[129]For example, some systems use inverted data files (EDMPAS and ENVIR) to expedite selective searching. Others allow the user to set up their own classification system (COVIRS), or create a data base specific to their immediate needs. Most interactive components of geographic information systems yield the latter type of flexibility.

[130]Ellis, "MIS", p. 3. An example is the two-variable maps produced by the MLMIS. IGU Study, chap. 6.

[131]Transferability generally refers to the potential for applying certain data handling capabilities to another set of problems and data handling requirements. It has no bearing, however, on whether or not the system meets a defined set of objectives or whether, in fact, objectives exist. Transferability is, hence, an objective in itself.

[132]Transferability was obviously neither a primary goal nor a critical factor in the following 'successful' systems:

- the Washington Coastal Zone Atlas
  (due to the required budget)

- ORRMIS
  (due to its scientific/user-specific design)

- LUNR
  (due to its scale inflexibility)

[133]The conceptual framework was presented in Section II (Table 2), and referenced repeatedly thereafter. See also the "Master Criteria List', (Table 1).

[134]This reflects the credibility of the system as perceived by the user. Refer to Section IV for a discussion

on system credibility.

[135]Tschanz and Kennedy, Guide, p. 58.

[136]This would include, for example, computer terminals with on-line or time-sharing access, and varying levels of interactive 'prompt' and 'query' modes of instruction. Also in this category are the 'self-contained' mini-computer systems, such as is used by the Rhode Island Coastal Zone Information System.

[137]See Section III.C.

[138]This points out the value of designing a system so different parts can function independently of others, as well as integrally. See notes 96 and 92 above.

[139]See notes 39 and 80 above.

[140]Tschanz and Kennedy, Guide, p. 58. See also n. 99 above.

[141]Ibid.

[142]See n. 86 above.

[143]"Scorecard" exemplifies a system delivered "as ordered", with little user/developer interfacing through its development and short operation period (see n. 53 above). Other advantages of the modular approach are mentioned in previous sections.

[144]See n. 97 above.

[145]For example, specialists are available to help outside users master systems including MERRMS, SEEDIS, and ENVIR. In the case of the Rhode Island Coastal Zone Information System, a special 'user-advocate' works directly with the developers in developing and implementing the various parts.

It should be noted that in-house projects not meant to serve outside users directly -- e.g; "CLAM", ORRMIS, Louisiana's "Information System", or Washington's "Shoreline Management [Permit Inventory] System" -- would not require the interfacing strategies called for in dealing with outside organizations during the development and/or later operational stages. (See also n. 57 above.) However, implementation measures to assure: 1) the appropriateness (relative to the decision-making framework and informational needs); and 2) the correct functioning of models and procedures (through sensitivity or other testing); would be necessary to demonstrate to the user-agency, the reliability and utility of their project. (Refer to the credibility discussion in Section IV.)

[146]See IGU Study, chap. 3; and Tschanz and Kennedy, Guide, p. 58.

[147]Instilling confidence in the user should be a prime objective during the development of an infcrmation system, as inferred throughout Section IV. See also n. 80 above.

[148]Tschanz and Kennedy, Guide, pp. 59-63.

[149]See the conceptual framework (Table 2) and user-oriented 'safeguards' (Section III.C).

[150]IGU Study, chap. 3.

[151]See Section III.C.

[152]Interfacing mechanisms are summarized under user-oriented 'safeguards'. See n. 133 above.

[153]Strome and Lauer, "An Overview", p. 326.

APPENDIX A

FOUR SETS OF EVALUATION CRITERIA

A limited number of comparative studies of environmental information systems is to be found. While this may reflect the real situation, it is most likely the result of poor publicity. For example, it is possible that more studies are performed than actually become available outside immediate investigating circles. The California Coastal Commission study, discussed later, fits this classification.

Despite the frequency with which new information systems are created, and preliminary state-of-the-art reviews are performed, little of substantive value is passed on to contemplators of similar ventures. Consequently, the rate of duplicating these initial critiques probably parallels that of encountering the same types of problems in developing new systems.

Four studies contributed to the formation of the conceptual framework (Table 2) and overall perspective for this thesis. The chief criteria used in each study to compare different information systems are tabulated below. While some criteria were considered important by all or most of the studies -- hardware, software, data needs, and information output, for example -- attention to other factors differed sharply. Such similarities or differences, necessarily, reflect the objectives and perspectives of each of the studies. The approaches taken by two studies, in particular, are discussed at length in an effort to further clarify the perspective of this thesis.

I. International Geographical Union Study

The Commission on Geographical Data Sensing and Processing of the International Gecgraphical Union (IGU) carried out an evaluation of five geographic information systems which represented the major computer-aided data handling techniques. The stated objective of the study was that of "objective appraisal". The approach involved: 1) identifying the total range of capabilities for data acquisition and manipulaticn for a set of perceived problems, and then 2) comparing the capabilties of given systems to this set. ((IGU) Study, p. 14.)

The product of the first task was a conceptual framework which permitted the "objective appraisals". This framework was also intended to serve as a guide to system design and, thus, mirrors the formal design methodology presented in Appendix B (Table 13). Table 8 summarizes the conceptual framework, or "informaticn system design and evaluation model", employed in the IGU study.

TABLE 8

INFORMATION SYSTEM DESIGN AND EVALUATION MODEL

<u>Stage 1</u>

1. Describe objectives, client, and client needs
2. Describe and evaluate data needs
3. Describe and evaluate geographic reference needs
4. Inventory existing data sources and collection programs
5. Inventory geographic referencing systems
6. Describe data set specifications
7. Describe information delivery requirements
8. Describe geographic referencing system
9. Evaluate system specifications and objectives

<u>Stage 2</u>

1. Describe alternative information needs
2. Describe hardware requirements
3. Describe software requirements
4. Describe operating environment
5. Evaluate feasibility and cost
6. Describe legal implications
7. Describe political implications
8. Evaluate legal and political implications

<u>Stage 3</u>

Final Evaluation:

1. Benefits
2. Costs
3. Impacts

(IGU Study, p. 16.)

The significance of the IGU study is its emphasis on methodology. This theme clearly reflects IGU's recognition that information systems must be geared toward specific users, and that the manner of doing this is extremely crucial. In describing the basic elements of information systems (see n. 21), the IGU study distinguished a "Management Subsystem". This 'component' is particularly relevant to the perspective of the present study, in the sense that certain "management functions [are] considered essential to the continuing success of any particular operation." (IGU Study, p. 17.) These 'management functions' are suggestive of some of the interfacing mechanisms considered in this thesis. The management subsystem consists of the aspects depicted in Table 9.

TABLE 9

MANAGEMENT SUBSYSTEM

1. long-term staff plan
2. fiscal plan
3. system publicity (e.g; via interim products)
4. education program for users
5. user-feedback system

(IGU Study, pp. 17, 20-22.)

The approach and perspective used in this thesis was similar to that described above. In both, specific elements of each system were evaluated in terms of their applicability to a model set of problems. This means that they were treated independent of other elements within the same system. 'Model solutions' - IGU's 'management subsystem' or the proposed 'conceptual framework' - provided a standard reference for judging individual elements. Due to the idealistic nature of these evaluations, and the variability among information systems, the present study acknowledged that no two systems could satisfy the exact mix of elements to the same degree. It is, in fact, the manner in which all elements are balanced that distinguishes different information systems. Thus, in both studies, deriving this 'model solution' was a prerequisite to carrying out the applicability tests on component criteria of various systems.

The studies specifically differ in two areas. First, the IGU study was technical in nature. It was "intented for specialists already acquainted with the principles of computer-aided data handling." (IGU Study, p.5.) The overall objective was a data encoding experiment which compared spatial data handling techniques on the basis of accuracy and cost. In contrast, the focus of the current investigation was on the qualitative, rather than quantitative, aspects of bringing natural resources information systems into a state of continued use. Hence, the approach was, at most, a 'subjective appraisal' of the methodologies -- or interfacing mechanisms -- required to accomplish this end.

Secondly, in keeping with the 'technical' and 'objective' intents, the IGU study examined only operational systems which had evidence of "a considerable degree of success" through their continued use. (IGU Study, p.7.) Whereas, the present study considered a heterogeneous sample of systems -- types, scopes, successful, unsuccessful -- from a nontechnical viewpoint (see Section II).

II. <u>A Guide to Design</u>

Tschanz and Kennedy compiled a guidebook for developing geographic information systems at state or regional scales. This guidebook was primarily intended for the use of resource managers. The nontechnical perspective matches that of the present study, particularly in emphasizing user-involvement in the design process. A systematic decision-making technique was offered as a mechanism for effecting this user-involvement. (See Section IV and Appendix B.)

The requirement that an information system be tied directly into the administrative structure, may be implicit in the approach taken by Tschanz and Kennedy, namely: designing the guidebook for resources managers. However, the point is given only minor weight relative to other criteria. The present study, on the other hand, assigns key importance to this aspect and, in fact, includes it within the conceptual framework of essential criteria (see Table 2). Because the guidebook lacks concrete examples, of the ramifications of both satisfactory and unsatisfactory attention to various criteria, the relative importance of individual criteria is difficult to discern.

The present study attempts to fill this void by conveying past and current experiences, tracing problems to specific causes, and deriving a conceptual framework which: 1) relates all criteria to primary objectives, and 2) facilitates having (to remember) to address a multitude of factors with every decision. This framework approach, plus the focus on interfacing, draws attention to five crucial considerations. Based on observed relationships between system usefulness and other criteria, these 'less crucial' criteria do, in fact, appear ancillary to the five key concepts. It is maintained that fulfillment of the gamut of 'important system development factors' -- both technical and nontechnical -- will follow, with adequate attention to the five essential criteria comprising the conceptual framework.

Table 10 summarizes the criteria Tschanz and Kennedy consider important to system development. Each task corresponds to a major step in the design methodology which is presented in Appendix B, (Table 13).

TABLE 10

DEVELOPMENT CRITERIA

Task 1

1. identify data elements
2. identify geographic location identifiers
3. identify user and user needs
4. determine user access arrangements and training

Task 2

1. identify and document available data
2. investigate geographic referencing system

Task 3

1. survey available procedures and equipment
2. procure hardware and software
3. set long-range staff plan
4. establish institutional setting

Task 4

1. determine data specifications
2. determine geographic referencing system
3. determine formal arrangements to accept, evaluate, and act on user-feedback
4. determine product delivery schedule
5. set data processing documentation plans

Task 5

1. determine transfer and storage alternatives
2. determine retrieval, analysis, and display alternatives
3. set long-range fiscal plan
4. set general operating policies

(Tschanz and Kennedy, Guide, pp. 65-83.)

As in the IGU study, Tschanz and Kennedy also isolate certain management functions. However, these management functions are exclusive of specific user considerations, or interfaces, which are addressed as a separate component cf system support. In contrast to the management subsystem depicted in the IGU study (Table 9), the management functions envisioned by Tschanz and Kennedy are listed in Table 11.

TABLE 11

MANAGEMENT FUNCTIONS

1. institutional setting
2. general policies for operation and maintenance
3. staff plan
4. fiscal plan
5. product publications plan for funding continuity (e.g; scheduling interim products and promotional techniques)
6. documentation (e.g; of all plans, programs, methodolcgies, interactions, and decisions)

(Tschanz and Kennedy, Guide, pp. 59-63.)

III. <u>South Carolina Coastal Plains Study</u>

The perspective of the Coastal Plains Study was regional, and the approach, technical. The study is unique in examining the state-of-the-art through questionnaires sent to state agencies in the coastal plains region. Based on a first draft review of the survey form by state representatives -- the states involved were Georgia, North Carolina, South Carolina, Virginia, and Florida -- the focus of the study shifted from data compatibility as the major issue, to the compatibility of information systems and the direction of geographic information systems development. (S.C. Coastal Plains Study, p. 67.)

Hence, the final objective of the study was twofold: 1) determine the present status of data collection and handling, e.g; "data compatibility/noncompatibility", and 2) specifically investigate and analyze on-going automated data handling activities, within the region. Again, the emphasis was on operational systems, as opposed to less successful, or inoperative efforts. But, unlike the two previous studies, particular attention was paid to socio-cultural and economic data items, in addition to the conventional environmental categories. An unanticipated, but recognized, secondary benefit of the study was in providing a means of matching information collectors and seekers in the area.

The criteria examined are tabulated below, under each of objectives (stated above).

Objective I - Identify

1. Data Sources - classification schemes (federal, state, etc.); data categorization; collection frequency; geographic coverage; display format; storage medium; standard referencing system; availability of access time and cost estimates of attaining data

2. Data Seekers - e.g; potential users of above

3. Maps - types; scales; geographic identifiers

Objective II - Examine

1. equipment used
2. software analytical and mapping capabilities
3. 'house-keeping' functions
4. types of geographic observations (point, line, area)
5. retrieval/display capabilities, including types of output

(S.C. Coastal Plains Study, chapters 3 and 4.)

IV. California Coastal Commission Study

The comparative study of information systems conducted by the California Coastal Commission, was part of a larger task to justify and guide the development of an automated information system in support of the state's developing coastal management programs. Although originally funded by

Sea Grant, the study remains incomplete following the expiration of these funds (in 1977). (Interview with Eric Metz, California Coastal Commission, San Francisco, California, 11 August 1978.) Several draft sections were provided for review, courtesy of Jens Sorensen (Sea Grant, University of California, Berkeley) with the understanding that these sections were subject to revision. The approach of the study appears to be systematic, mixing both technical and nontechnical considerations, and the perspective, local and state systems. Some subjectivity was evident in the study's critique of alternative approaches to system development and operation, and was acknowledged as such in drawing conclusions in the present study.

Briefly, eight geographic information systems were evaluated, based on the following characteristics:

1. sponsoring agency and funding sources
2. location/areal coverage
3. legislative mandate
4. variables encoded/map scales
5. geographic attributes: address; sampling method; resolution
6. software (interactive capabilities) and hardware (devices)
7. specific planning task objective
8. analysis performed and output obtained
9. planning products
10. past and present users

11. implementation status and future use

(Calif. Coastal Study, Section II. C.)

APPENDIX B

FOUR SYSTEMATIC DECISION-MAKING TECHNIQUES

I. Procedural Guidelines for System Design

Tschanz and Kennedy (*Guide*, pp. 65-80) proposed guidelines for constructing a formal procedure for designing individual information systems. According to the authors, this design procedure organizes all efforts toward a systematic matching of needs and capabilities. It also facilitates carrying out the details of the design process. As noted,

> "...the design process is the tailoring of a combination of technical elements and administrative structure into a system that will satisfy the information demand within resource (time, money, manpower), legal, and organizational constraints." (*Guide*, p. 65)

Due to the importance of pre-proposal decisions, two phases within the design process were distinguished: 1) initiation of the design process, and 2) formal design methodology. The foundation for decision-making throughout both 'phases', however, is set initially in an "iterative process" of testing alternative capabilities against overall objectives. With successive iterations of the consensus-reaching procedures, aspects of system design are examined in greater and greater detail and technical complexity, until a commitment can be made to specific plans. This "iterative process" is reproduced in Table 12.

TABLE 12

ITERATIVE PROCESS FOR INFORMATION SYSTEM DESIGN

<u>First Iteration</u>
Resources manager; on-paper; short time frame.
Manager's concepts and knowledge of all aspects.
Result: stop or proceed with design.

<u>Second Iteration</u>
Resources manager, small group (e.g; developers); on-paper; short time frame.
Collective concepts and knowledge of all aspects.
Result: stop or proceed with design.

<u>Third Iteration</u>
Study group formed; on-paper; few months.
Consensus on objectives; individual study teams for tasks; structure decisions, interrelationships, and options.
Formulation of specifications and technical operations alternatives.
Result: a set of possibilities for detailed investigation and evaluation.

<u>Fourth Iteration</u>
Same as above with detailed emphasis on investigations and evaluation; decisions formulated.

SUCCESSIVE ITERATIONS WILL BE NEEDED

(Tschanz and Kennedy, <u>Guide,</u> p. 66.)

Table 12 depicts the few iterations of the design process. Significant in this general strategy, is the emphasis on the involvement of the user-agency in 1) identifying informational needs, and 2) electing to build an information system. Once the need and specific objectives for a system have been established, the iterative process is applied to the various components. However, in the latter tasks, ideas will generally originate within the technical faction of the study group. Tschanz and Kennedy advise that, because decisions of a technical nature are often made outside the user-agency, "such a systematic design process with documentation is all the more important to ensure continuity of effort." (Guide, p. 65.)

The formal design methodology (Table 13) is initiated only after a list of initial objectives for system development is produced (through the iterative design process). The systematic approach in Table 13 is typical of that followed by many developers and is included in this discussion for that reason only. The atypical quality of the methodology perceived by Tschanz and Kennedy, however, is the participation of the end-user in all decisions (to the degree possible), plus the standard approach to effecting these decisions. This instruction in 'how' is omitted in the majority of design methodologies -- which, accordingly, would be more appropriately termed 'design schedules'.

TABLE 13

FORMAL DESIGN METHODCLOGY

TASK	
1	Determination of system objectives
2	Assessment of data availibility
3	Assessment of available procedures, equipment and manpower resources
4	Determination and evaluation of system specifications
5	Structure and evaluation of technical operations alternatives
6	Overall evaluation and selection of a system

(Tschanz and Kennedy <u>Guide,</u> pp. 65-80.)

The above tasks are, necessarily, carried out relative to the basic elements of information systems (see n. 21). II.

Dispute-Resolution Techniques

Donald B. Straus, of the AAA, offers a unique set of methods for resolving environmental disputes -- a dispute being "an incident in the problem-solving cycle." ("Mediating Trade-Offs", p. 10.) The notion of dispute-resolution has particular potential in the area of information system development, and the methods have, in fact, been applied to data validation efforts in developing the IIM (see Section IV). Deciding on system objectives, as well as design alternatives, would be prime areas in which to apply the problem-solving scenario delineated by Straus.

Straus represents the basic "problem-solving cycle" as a succession of stages leading to a solution or a decision.

These stages include:

Awareness of a problem

Analysis of the facts and data to determine which are relevant and accurate

Development of various alternative solutions

The game of "what if" -- testing various alternative solutions

Discovering differing preferences for different solutions

Identifying friends and opponents around various solutions

Seeking agreement among the differing points cf view

Determining whether to comprcmise or withdraw or strike or fight

Reaching a decision

Living with the decision and becoming aware of the various impacts

Becoming aware of a new set cf problems

The cycle repeats

The key to Straus' model seems to be the observation that disputes may occur at almost any stage in this master cycle. Thus, in settling major issues, it often becomes necessary to stop and make various sub-decisions. Importantly, each sub-decision is handled in the exact fashion as its encompassing question.

The techniques Straus perceives as remedial to different kinds of disputes include the following:

Gathering facts

Analyzing facts

Discussions, meetings, negotiations

Creating alternative sclutions

Seeking third party assistance

Facilitation *

Fact-finding

Mediation **

Arbitration

Voting procedures

Resort to the courts

Striking

Use of economic pressure

Withdrawing from the contest

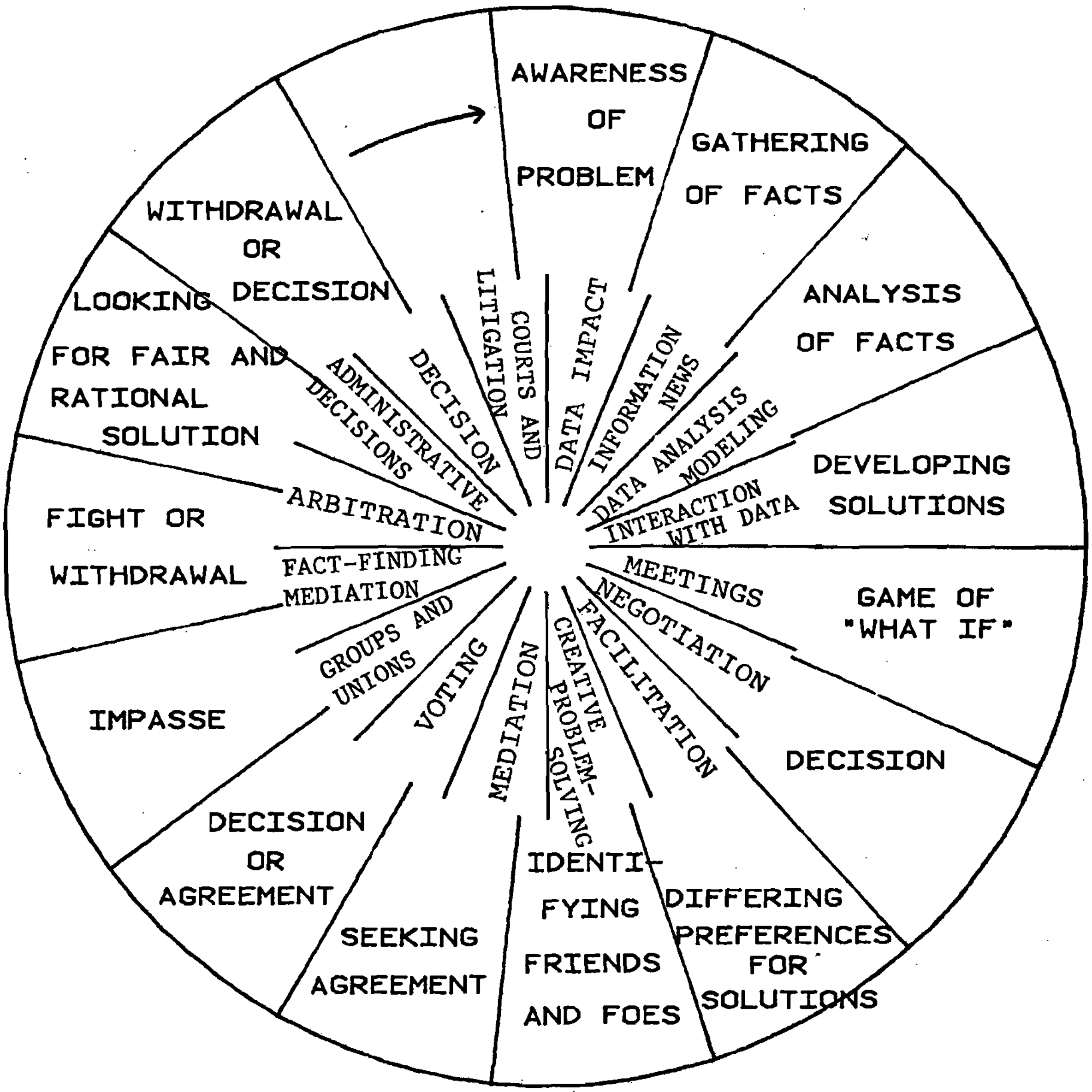
* Facilitation, an emerging technique for making meetings more productive, entails third-party involvement in dispute-settlement. More specifically,

> "Neutral and nonevaluating, the facilitator is responsible for making sure the participants are using the most effective methods for accomplishing their task in the shortest time.....The facilitator offers a menu of possible ways of attacking the problem, and waits until there is agreement on one particular process. Then the facilitator helps keep the group on track until it has accomplished what it set out to do or wants to change direction." ("Mediating Trade-Offs", p. 8.)

** "Mediation...is the activity of a neutral person skilled in using the available techniques for producing consensus, and in using them at the most effective time and stage in the process of solving problems." ("Mediating Trade-Offs", pp. 8-9.)

The approach is to choose and apply any one of the techniques to an immediate problem (or set of problems). This relationship is illustrated in Figure 1. The obvious

Figure 1: Matching a Technique with the Dispute Being Managed



difficulty for new proponents of this process would be in choosing an appropriate technique for a given question. Hence, during initial experimentation with this consensus-reaching strategy, third-party assistance would be the likely route.

Due to the traditions of prolonging dispute negotiations and/or withholding third-party intervention until an impasse arises, it is reccmmended that the techniques be applied "flexibly" and as soon as a dispute can be identified. ("Mediating Trade-Offs", pp. 13-14.)

Two final notes on the application of Straus' techniques to information system design decisions: First, the objective is to reach a consensus on the actions chosen. This, necessarily, must involve the parties relevant to the decisions being made. In the case of information systems, these parties would include the end-users, system developers, and any support or consulting individuals deemed necessary to the effort. Secondly, the approach is new. As such, it will be subject to the basic reluctance given any new procedure (see n. 89), and should be introduced with this awareness.

III. Interpretive Structural Modeling

While the Interpretive Structural Modeling (ISM) technique has broad applications in the areas of issue analysis, data (or information) assimilation, and policy analysis, its use in conjunction with information systems -- and environmental management programs, in general -- has been limited. Louisiana's Coastal Resources Program applies the method toward answering the ultimate question of 'where to develop' in the coastal region. ISM has become an integral part of the state's "Information System", as a result, and provides a computer-assisted, systematic approach to environmental planning and management decisions. There is no reason to believe that the same methodologies could not also be effective in directing the development of an information system, itself.

Paul H. Templet, (in "Louisiana's Information System"), describes the use of ISM in the task of determining the relevance of 32 different variables to constraining development:

> "This technique is one which is designed to help people think and communicate more effectively about complex issues. There are three basic operational steps involved in application of the technique. Given (1) an issue context, the first task is to extract a set of (2) relevant elements and (3) a meaningful relational statement...." (Templet, "La.'s Information System", p. 3.)

The operational steps are summarized in Table 14. The "relational statement" is repeatedly tested among all possible pairs of "relevant elements", manually --

TABLE 14

BASIC OPERATIONAL STEPS FOR APLICATION

OF THE ISM TECHNIQUE

Input: Issue Context

Step 1

Generate an element list and a relational statement

Step 2

Use computer aids to systematically create a directed graph

Step 3

Review, revise, and iterate as appropriate, then introduce interpretive symbols to create an interpretive model

Output: Interpretive Structural Model

(Templet, "La.'s Information System", p. 8.)

(e.g; subjective judgements by a panel of experts). For example, Templet's group ranked all of 32 variables in this way, using the relational statement: "Is _(variable x)_ more imporatant than _(variable y)_ in constraining development." The computer was then employed in structuring the manifold rankings into a relational pattern, or "directed graph". The purpose of this intermediate step is to determine whether additional iterations, with revised elements sets or relational statements, are required to create a more realistic or pertinent pattern. The final product, an interpretive structural model, is a computer-processed, graphic representation of the rankings. Maps are produced as the result of applying the ISM techniques to coastal development questions in Louisiana.

The above is but a cursory view of the ISM process. The idea for such an approach, in fact, evolved in the early 1970's and has since grown into a comprehensive technique with a history of varied applications. Templet refers interested persons to Battelle's Columbus Laboratories (Columbus, Ohio), for a substantive account of ISM.

The value of ISM to decision-making, in general -- but to making decisions about information systems, in particular -- parallels that of Straus' techniques for dispute-settlement. The incorporation of the considerations listed below, give both methods great potential in many areas of information system design.

1. questions are examined in the context of 'mental models'

2. problems are broken into digestable elements and quantified where possible

3. communication among factions is facilitated

4. the process is systematic, step-by-step, and appropriately documented

5. end-users are involved in consensus-reaching activities from the beginning

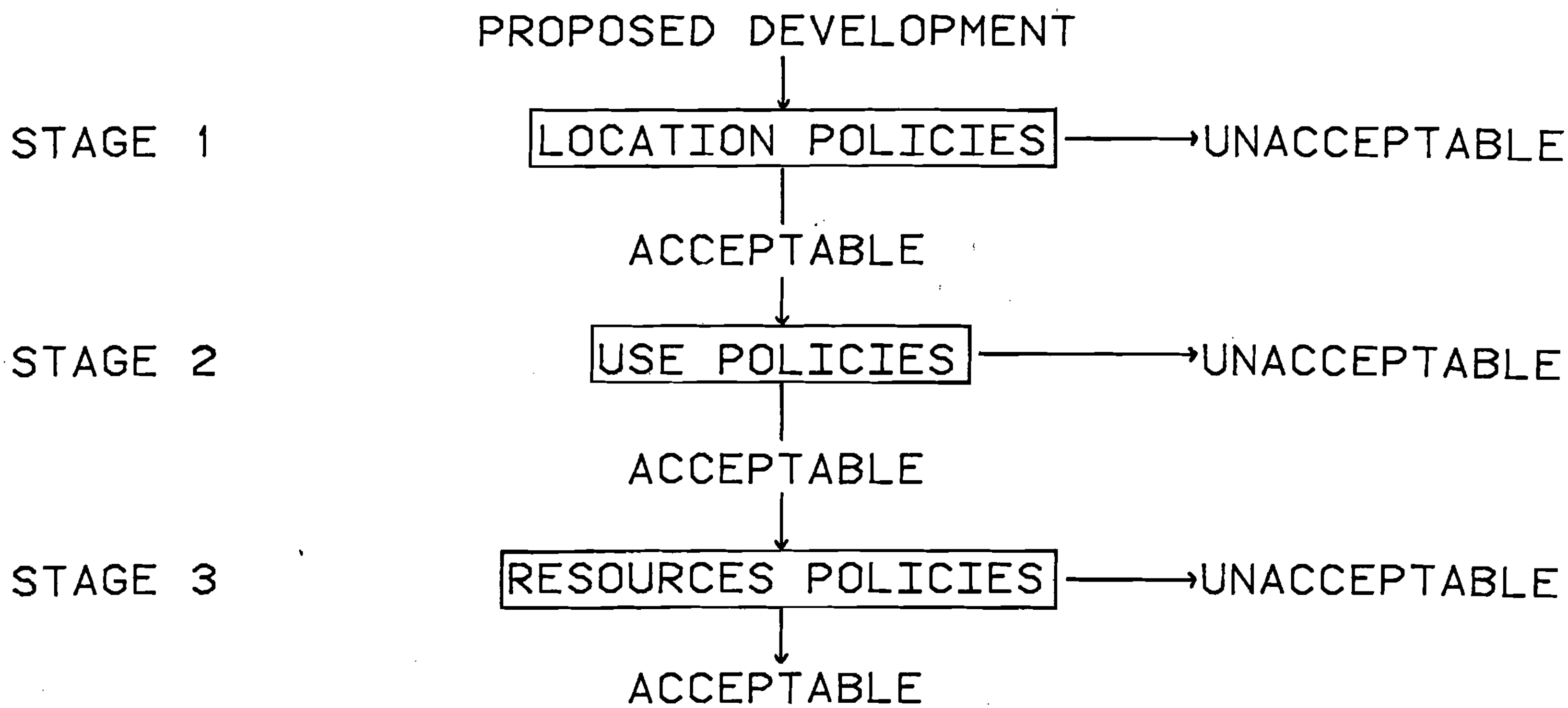
IV. "CLAM"

The Coastal Location Acceptability Method is a process of evaluating the suitability of different coastal areas for development. It is an integral activity within the decision-making framework of the New Jersey Coastal Management Program (Bay and Ocean Shore Segment), and is carried out by the state's OCZM in the Division of Marine Resources, Department of Environmental Protection (see Figure 2). "CLAM" is neither as versatile (since it is specific to management decisions), nor as germane to information system design decisions, as the three previous techniques. However, it is included in this discussion because it is unique among systematic decision-making techniques. "CLAM" also represents one of the most successful information systems developed for natural resources management. The reasons are discussed below.

First, "CLAM" is a decision-making process. Most

Figure 2: NEW JERSEY'S

<u>COASTAL MANAGEMENT DECISION-MAKING PROCESS</u>



(<u>N.J. CMP</u>, P. 22.)

importantly, it names the parties relevant to the decision being made and requires their participation. These qualities -- a systematic approach and the recruitment of crucial players -- distinguishes "CLAM" (and also the ISM, as used by Louisiana's Coastal Resources Program), from conventional decision-matrices, which appear in the few formal design methodologies for information systems. [For example, the IGU Study (chap. 2), and the designers of MIS and CRIP (neither of which were implemented), proposed methodologies of the 'conventional' type.]

"CLAM", thus, fits into the general class of consensus-reaching methodologies. However, unlike Louisiana's use of ISM -- for purposes nearly identical to that of "CLAM" -- the latter technique was developed in-house. As a result, it would have little relevance to decision-making outside the area of primary concern, namely: coastal development, (both policy-making and enforcement).

Secondly, "CLAM" is an information system, in the sense that it provides information required for making specific types of decisions. "CLAM" is used in conjunction with clearly defined "Location Policies", during stage one of the screening process (see Figure 2). The result is an indication of where developments may take place.

The process itself, is carried out in eight steps. For each proposed coastal development, the Location Policies require, overall: 1) the identification of site attributes (e.g; physical, critical, 'valued'), 2) the preparation of maps, and 3) a determination of the development potential of the site, or the advantages for development. As stated in the management program (p. 24), "The eight steps of analysis begin at the wettest part of the coastal region and proceed upland to the driest areas."

These steps include:

<u>Identify and Map</u>

1. Special Water Areas
2. Water Areas
3. Water's Edge and Land Areas
4. Water's Edge Areas
5. Land Areas

<u>Prepare</u>

6. Composite Map
7. Location Acceptability Map

<u>Determine</u>

8. Location Acceptability

(<u>N.J. CMP,</u> pp. 24-26.)

If development is deemed acceptable, the project is allowed to proceed to the next stage in the screening process. The final two stages determine, respectively, 'what' may take place, and 'to what extent' it may occur, on the location in question.

Finally, the eventuality that "CLAM" will be adopted as part of the rules and regulations of the management program, not only formally ties this system into the administrative framework, but ensures its continuation. Extensive measures have been taken to document data sources and accuracy, analytical procedures, policy rationale, and definitions pertinent to resources decisions and management. (N.J. CMP, chap. 3 and Appendix N; and Wiener, interview.) It is flexible in carrying out the "Basic Coastal Policies" at both the regional and site-specific scales. The function of "CLAM" as an interfacing mechanism, is clear in the systematic approach to accessing needed information to particular users, in an understandable format. In fact, the credibility of the method speaks for itself. The Coastal Management Program (p. 23) encourages that:

> "Any interested person should be able to fill in the characteristics of a particular site or development project to determine its acceptability under the Coastal Program."

It is expected that "CLAM" will be further refined upon the approval of the Coastal Management Program. (Wiener, interview.) Due to the success of this system, already, in bringing together users at all levels -- prospective developers, DEP staff, other public agencies, and interested citizens (N.J. CMP, p. 23) -- it is highly probable that future adaptations of "CLAM" will be the result of more constructive feedback and group consensus, than is initially given developing coastal management programs. In this sense, "CLAM" may also inspire a structured approach to improving the system -- e.g; a formal decision-making methodology for system design.

ABBREVIATIONS

SYSTEMS

CLAM	Coastal Location Acceptability Method
CLUIS	South Carolina Computerized Land Use Information System
COVIRS	Classified and Organized Verbal Information Retieval System
CRIP	Critical Resources Information Program
EDMPAS	Environment-Dependent Management Process Automation and Simulation System
EMDAS	Environmental Management Decision Assistance System
ENVIR	Environmental Information Retrieval System
IIM	Intuitive Interactive Model
LUNR	Land Use and Natural Resources Information System
MERRMS	Marine Environment and Resources Research and Management Information System
MIS	Marine Information System
MLMIS	Minnesota Land Management Information System
NEEMIS	New England Energy Management Information System
ORRMIS	Oak Ridge Regional Management Information System
PLUM	North Carolina Planning and Management System
RAEG	Rapid Access to Environmental Guidance
SEEDIS	Socio-Economic Environmental Demographic Information System
UPGRADE	User-Prompted GRAphic Data Evaluation
UVAIS	University of Virginia Information System

OTHER

AAA	American Arbitration Association
CAPS	Center for Aerial Photographic Studies
CEQ	Council on Environmental Quality
CMP	Coastal Management Program
CRAG	Columbia Region Association of Governments
CRC	Coastal Resources Center
CRMC	Coastal Resources Management Council
CURA	Center for Urban and Regional Affairs
DEM	Department of Environmental Management
DEP	Department of Environmental Protection
DOA	Department of Administration
DOE	Department of Ecology
EDIS	Environmental Data and Information Service
HUD	Housing and Urban Development
IGU	International Geographical Union
ISM	Interpretive Structural Modeling
LCOG	Lane Council of Oregon Governments
MAS	Marine Advisory Service
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf
OCZM	Office of Coastal Zone Management
ONR	Office of Naval Research
OPC	Office of Planning Coordination
OPS	Office of Planning Services
RCIC	Regional Coastal Information Center

RESA	Regional Environmental Systems Analysis
SPA	State Planning Agency

BIBLIOGRAPHY

Austin, Thomas s. "Challenges for Meeting Public Needs for Science Information." Environmental Data Service (November 1977).

California Coastal Commission. "Comparison of Information Systems." San Francisco: California Coastal Commission 1977. (Incomplete draft report.)

Cheney, Philip B. "The Development of a Procedure and Knowledge Requirements for Marine Resource Planning: Functional Step Two, Knowledge Requirements." Prepared for the Regional Marine Resources Council, Nassau-Suffolk Regional Planning Board. Hartford, CT.: Travelers Research Corp., February 1970.

Cheney, Philip B. "High Priority Research and Data Needs: Interim Functional Step Four." Prepared for the Regional Marine Resources Council, Nassau-Suffolk Regional Planning Board. Hartford, CT.: Center for the Environment and Man, Inc., November 1970.

Council on Environmental Quality. "The UPGRADE System." Brochure on the User-Prompted GRAphic Data Evaluation System. Washington, D.C.: CEQ, March 1977.

Council on Environmental Quality. "The UPGRADE System: User's Overview." Draft report on the User-Prompted GRAphic Data Evaluation System. Washington, D.C.: CEQ, September 1977.

Daugherty, Richard. Science in Geography 2: Data Collection. London: Oxford University Press, 1974.

Dedera, Don. "Computing the Quality of Life." Exxon USA. (Third Quarter, 1977).

Department of Ecology, State of Washington. "Overview of Data Processing System." Olympia, Wash: Management Section of Shorelands Division, DOE, September 1976.

Dolan, R.; Felder, W.N.; and Hayden, B.P. "Design of a Coastal Information System." Naval Research Reviews 30 (November 1977).

Donovan, John J., and Jacoby, Henry D. "Virtual Machine Communication for the Implementation of Decision Support Systems." IEEE Transactions on Software Engineering SE-3 (September 1977): 333-342.

Ellis, Max ., and Bunde, Dennis C. CRIP: Critical Resource Information Program, Processing and Analysis of Resource Data for CRIP, Report Five. Prepared for the Wisconsisn Department of Administration, Bureau of Planning and Budget. Madison, Wisc: University of Wisconsin, October 1973.

Ellis, R.H.; Cheney, P.B.; Ball, J.T.; and Sweeton, E.R. "The design of a Management Information System for Coastal Resources Planning." Prepared for the Regional Marine Resources Council, Nassau-Suffolk Regional Planning Board. Hartford, CT.: Center for the Environment and Man, Inc., February 1972.

Ellis, R.H.; Cheney, P.B.; Smith, F.A.; Davis, R.M.; and Brush, R.O. "The Development of a Procedure and Knowledge Requirements for Marine Resource Planning: Functional Step One." Prepared for the Regional Marine Resources Council, Nassau-Suffolk Regional Planning Board. Hartford, CT.: Travelers Research Corp., April 1969.

Greenberg, Michael R. Intuitive-Interactive Model Permit Text. New Brunswick, N.J.: Rutgers University, January 1977.

Gulf Universities Research Consortium. "EDMPAS, A Data Information System for Environment-Dependent Management Process Automation and Simulation: Computer Software for the Integration of Environmental Factors into the Management Process." Houston, TX: Gulf Universities Research Consortium, 1972.

Hardy, Ernest E. "Design Concepts for Comprehensive Resources Information Systems." Presented at COMS/NOAA (Sea Grant) Conference on "Formulating Marine Policy: Limitations to Rational Decision-Making, 19-21 June 1978." University of Rhode Island, Narragansett Bay Campus, Narragansett, Rhode Island.

Hardy, Ernest E. Inventorying New York's Land Use and Natural Resources." Food and Life Sciences Quarterly 3 (October - December 1970).

Heikoff, Joseph M. Coastal Resources Management: Institutions and Programs. Ann Arbor, Mich.: Ann Arbor Science Publishers, Inc., 1977.

Holmes, Harvard. "SEEDIS: Socio-Econcmic Environmental Demographic Information System." Presented at COMS/EDIS Workshop on Information Systems for Coastal Zone Management, 22-23 June 1978. University of Phode Island, Alton Jones Conference Center, Exeter, Rhode Island.

International Geographical Union. Computer Handling of Geographical Data. Report by the Commission on Geographical Data Sensing and Processing of the International Geographical Union, with the cooperation of Unesco and governmental agencies in Canada and the United States. France: Unesco Press, 1976.

Jones, J.C. "MERRMS - A Marine Environment and Resources Research and Management System." Presented to the Conference on Marine Resources of the Coastal Plains States, 10 December 1976. Jacksonville, Florida.

King, Lauriston, R. "The international Decade of Ocean Exploration Program in Marine Science Affairs." MIS Journal 11 (December 1977).

Lillesand, T.M., and Tyson, W.K. "Addressing the Remote Sensing 'Data-Information Gap': Overhead Monitoring in New York's St. Lawrence River - Eastern Lake Ontario Coastal Zone." Proceedings of the Tenth International Symposium on Remote Sensing of the Environment. Mich: Environmental Research Institute of Michigan, University of Michigan, 1975.

Lowe, J.C., and Moryadas, S. The Geography of Movement. Boston, MA.: Houghton Mifflin Co., 1975.

MacBeth, Angus. "Modeling in the Context of the Law." In Ecosystem Modeling in Theory and Practice: An Introduction with Case Histories. Edited by C. Hall, and J. Day, Jr. New York: John Wiley and Sons, 1977.

Minnesota Land Management Information Center. "MLMIS Overview: Chapter 1." St. Paul, Minn.: +State Planning Agency, January 1978.

Minnesota Land Management Information Center. North Shore Data Atlas: Minnesota Coastal Zone. St. Paul, Minn.: State Planning Agency, 1977.

McNeil, Donald R. Interactive Data Analysis: A Practical Primer. New York: John Wiley and Sons, Inc., 1977.

Merselis, William B., ed. Proceedings: Coastal Zone Management and the Western States Future, 3-4 December 1973. Marine Technology Society, 1974.

Natural Resources Defense Council, Inc. Land Use Controls In the United States: A Handbook on the Legal Rights of Citizens. Edited by Elaine Moss. New Jersey: The Dial Press/James Wade, 1977.

New Jersey Department of Environmental Protection. "New Jersey Coastal Management Program - Bay and Ocean Shore Segment and Draft Envirnmental impact Statement." Trenton, N.J.: Division of Marine Services, OCZM, May 1978.

O'Connor, Dennis M. "COVIRS: Classified and Organized Verbal Information Retrieval System." Presented at COMS/EDIS Workshop on Information Systems for Coastal Zone Management, 22-23 June 1978. University of Rhode Island, Alton Jones Conference Center, Exeter, Rhode Island.

O'Connor, Dennis M. "Information Management for Environmental Decisions: A Final Report on Development of Improved Methodologies and Advances in the State of the Art for Law/Economics in Environmental Data Management." Florida: GURC/NASA, April 1972.

Pleasants, J.B. "The Marine Environment and Resources Research and Management System: MERRMS." Proceedings of the Conference on Tools for Coastal Zone Management, 14-15 February 1972. Washington, D.C.: Marine Technology Society, 1972.

Pleasants, J.B. "The Marine Environment and Resources Research Management System at the Virginia Institute of Marine Science (MERRMS at VIMS)." Presented at COMS/NOAA (Sea Grant) Conference on "Formulating Marine Policy: Limitations to Rational Decision-Making, 19-21 June 1978." University of Rhode Island, Narragansett Bay Campus, Narragansett, Rhode Island.

Rea, Cary. "UVAIS: The University of Virginia Coastal Information System: A Data and Mmdel Index for the Office of Naval Research. Geography Programs." Presented at COMS/EDIS Workshop on Information Systems for Coastal Zone Management, 22-23 June 1978. University of Rhode Island, Alton Jones Conference Center, Exeter, Rhode Island.

Rosenfeld, M.A. "Marine Data Management - The Views of University Scientists." Proceedings: International Marine Information Symposium, 31 October - 1 November, 1968. Marine Technology Society, 1969.

Ross, P.B., and Rea, C.C "Handbook for the University of Virginia Coastal Information System." Virginia: University of Virginia, November 1977.

Rowe, P.G.; Gevirtz, J.L.; and Weichert, P. "A Natural Environmental Information and Impact Assessment System." Transactions, 27th Annual Meeting, Gulf Coast Association of Geological Societies, (October 1977).

Rowe, P.G.; Gevirtz, J.L.; and Weichert, P. "An Envirnmental Management Decision Assistance System for Local Government." Proceedings, 15th Annual Conference, Urban and Regional Information Systems Association. (August 1977).

Russell, Clifford S., and Kneese, Allen V. "Establishing the Scientific, Technical, and Economic Basis for Coastal Zone Management." CZM Journal 1 (January 1973): 47-63.

Schneidewind, Norman F. "Information Systems and Data Requirements: Coastal Development Planning." In ocean Engineering, Goals, Environment, Technology. Edited by J. Brahtz. New York: Wiley, 1968.

Smith, Willard J. "Paradoxes Regarding Oceanographic Data Acquisition -- Are They Insurmountable?" Proceedings: International Marine Information Symposium, 31 October - 1 November, 1968. Marine Technology Society, 1969.

South Carolina Wildlife & Marine Resources Department. Coastal Plains Regional Resource Information System Study." Prepared for the Coastal Plains Regional Commission. South Carolina: Wildlife & Marine Resources Department, January 1978.

Spaulding, M.; Cornillon, P.; and Knapp, C. "A Coastal Zone Information System for Rhode Island." Presented at COMS/EDIS Workshop on Information Systems for Coastal Zone Management, 22-23 June 1978. University of Rhode Island, Alton Jones Conference Center, Exeter, Rhode Island.

Straus, Donald B. "Mediating Environmental, Energy and Economic Trade-Offs: A Case Study of the Search for Improved Tools for Facilitating the Process." Presented at the AAAS Symposium on Environmental Mediation Cases, 20-25 February 1977. Denver, Colorado.

Strome, W.M., and Lauer, D.T. "An Overview of Remote Sensing Technology Transfer in Canada and the United States." _Proceedings of the Eleventh International Symposium on Remote Sensing of the Environment._ Michigan: Enivronmental Research Institute of Michigan, University of Michigan, 1977.

Teknekron, Inc. "System Description of the Proposed RAEG System (Rapid Access to Environmental Guidance)." Excerpted from _Teknekron Phase II Report._ Prepared for the Conservation Foundation. Maryland: Teknekron, Inc., June 1976.

Templet, Paul H. "Discussion of Louisiana's "Information System"." Presented at COMS/EDIS Workshop on Information Systems for Coastal Zone Management, 22-23 June 1978. University of Rhode Island, Alton Jones Conference Center, Exeter, Rhode Island.

Tschanz, J.F., and Kennedy, A.S. _Natural Resource Management Information Systems: A Guide to Design._ Argonne, Ill.: Argonne National Laboratory, July 1975.

Weinberg, Gerald M. _An Introduction to General Systems Thinking._ New York: John Wiley & Sons, Inc., 1975.

INTERVIEWS

Conservation Foundation. Washington, D.C. 9 August 1978.

Cook, Glen. Genessee Finger Lakes Regional Council, Rochester, New York. 15 August 1978.

Crowder, Robert. New York Office of Planning Services, Economic Development Board, Albany, New York. 8 September 1978.

Donovan, John J. Energy Laboratory, Alfred P. Sloan School of Management, Massachusetts Institute of Technolcgy, Cambridge, Massachusetts. 13 January 1978.

Durfee, Richard C. Computer Sciences Division, Oak Ridge National Laboratories, Oak Ridge, Tennesse. 22 August 1978.

Greenberg, Michael. Division of Urban Studies, Rutgers University, New Brunswick, New Jersey. 5 July 1977.

Jones, Claiborne J. Virginia Institute of Marine Science, Gloucester Point, Virginia. 16 June 1977.

Leopold, Larry. uSC Sea Grant Program, Marine Advisory Service, Wilmington, California. 3 August 1978.

Metz, Eric. California Coastal Commission, San Francisco, California. 11 August 1978.

Nieman, Bernard J. Department of Landscape Architecture, University of Wisconsin, Madison, Wisconsin. 8 September 1978.

Oppenheimer, Carl. Marine Science Institute Laboratory, University of Texas, Port Aransas, Texas. 11 August 1978.

Pratt, Leighton. Department of Ecology, Olympia, Washington. 2 August 1978.

Rowe, Peter, G. Environmental Program, Southwest Center for Urban Research, Houston, Texas. 1 February 1978.

Rundlett, M. Department of Ecology, Olympia, Washington. 9 August 1978.

Weiner, Saul. Sr. Landscape Architect - Planning Coordinator, Office of Coastal Zone Management, New Jersey Department of Environmental Protection, Trenton, New Jersey. 21 August 1978.

OTHER

"Workshop on Information Systems for Coastal Zone Management." Sponsored by the Environmental Data and Information Service and the Center for Ocean Management Studies, University of Rhode Island. Held at the Alton Jones Conference Center, University of Rhode Island, Exeter, Rhode Island, 22-23 June 1978. Notes of discussions. (Typewritten.)